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Photovoltaics, a driving force for industrialisation

ANNUAL REPORT 2025

GOBIERNO DE ESPAÑA
MINISTERIO DE ECONOMÍA, COMERCIO Y EMPRESA
ICEX INVESTIN SPAIN

Letter from the Chairman

Rafael Benjumea
Chairman of Unión Española Fotovoltaica (UNEF)

Dear member companies,

As we present our 2024 Annual Report, I am pleased to share with you a review of the year. Despite facing challenges, this period has reinforced the leading role of photovoltaic solar energy in the Spanish energy system.

The year 2024 will be remembered as a milestone for our sector. For the first time, photovoltaic energy topped the Spanish electricity mix, maintaining this position for four consecutive months, from May to August. This achievement reaffirms its status as essential technology for our energy transition and highlights the maturity our industry has reached.

In terms of installations, Spain added 6,039 MW of new ground-mounted photovoltaic capacity in 2024, bringing the total to 32,157 MW. However, the self-consumption sector has faced challenges, experiencing a 31% drop in installed capacity compared to 2023, with 1,182 MW added during the year. This brings the total to 8,137 MW. This situation reminds us that while we've made significant strides, we are still far from the 19 GW target set for 2030 by the National Integrated Energy and Climate Plan (PNIEC) for self-consumption.

The year ended with the devastating impact of the DANA in Valencia, a stark reminder that the climate emergency is upon us and affecting our lives. This tragedy underscores the urgent need to accelerate the energy transition. It shows that the solution is not in denial but in pursuing excellence in our practices and in our relationship with society. We must generate wealth and opportunities for local communities while protecting the environment and promoting biodiversity.

This year, UNEF has reinforced its role as the leading association in the photovoltaic and storage sector, representing over 800 member companies spanning the entire value chain.

We have been actively engaged in the regulatory arena. In particular, we have focused on easing milestone requirements, streamlining the processing of appeals, and modifying RECORE to address the massive influx of zero and negative hours. We have also consistently advocated for auction announcements to help mitigate project difficulties caused by the impact of negative hours on business models.

In terms of institutional relations, UNEF has become the key representative of the photovoltaic sector with MITERD and established a direct communication line with the office of the Minister of Economy and Trade. We have strengthened connections with spokespersons from all parliamentary groups and maintain direct dialogue with REE/REDEIA. At the regional level, the Network of Regional Energy Directors and UNEF have jointly sent a letter to the minister to expedite the development of storage solutions in Spain.

We have achieved significant progress in advancing storage processes regionally, driven by UNEF's proposals, and are promoting these improvements across other autonomous communities and with MITERD. We have also developed a seal of excellence in storage to set the benchmark for best practices in the sector. UNEF has been a pivotal player in securing storage subsidies through submissions and meetings with IDAE and by closely monitoring the PRTR call for proposals. Additionally, we have prepared submissions for the long-awaited capacity market, reinforcing our role as a key player in the regulatory development of this technology, which is crucial for the stability of the electricity system.

In the self-consumption sector, in light of the recorded 31% decrease, we are actively working on regulatory measures based on our ten-point self-consumption plan. The public consultation held in October 2024 offered a crucial opportunity to align regulations with the sector's current needs, and a draft of the new Royal Decree is anticipated following this consultation. Regarding energy communities, we have created a comprehensive document of regulatory proposals to address the lack of a complete regulatory framework. This document has been presented to the IDAE, regional governments, and parliamentary groups to ensure these stakeholders can participate equally in the electricity system. In the field of agrovoltaics, we have launched pioneering initiatives, making significant progress towards having agrovoltaic areas recognised as eligible under the CAP.

I want to highlight that the early months of 2025 have confirmed both the challenges and opportunities we identified in 2024. The widespread outage last April underscored the challenges facing the electricity system and validated the direction of our efforts in 2024: the urgent need to accelerate storage deployment, enhance the grid, and capitalise on the potential of photovoltaics to make the system more stable and resilient.

The challenges ahead are clear: addressing demand patterns that lead to energy prices deterring investment, accelerating electrification (which is more pressing than ever from both an environmental and economic opportunity perspective), promoting the deployment of storage, enhancing social acceptance, and overcoming regulatory barriers that have emerged in some autonomous communities.

However, we also have unique strengths to leverage: we are a sun-rich country just when solar energy is needed most, with over 2,000 hours of sunshine annually, making our projects twice as profitable as those in other European countries. Our well-established industry contributed €15.317 billion to both national and international GDP in 2024, and it leads in innovation and internationalisation. We already know that these projects are boosting population, employment, and income in rural Spain.

I want to sincerely thank all our member companies for their trust and ongoing support, especially during such a challenging year. Your commitment remains the driving force behind our sector. I also extend my thanks to the UNEF team and the Board of Directors for their unwavering dedication and strategic vision.

At UNEF, we play a pivotal role in the sector, working tirelessly to ensure photovoltaic energy remains a key driver of the energy transition and economic competitiveness, and contributes significantly to building a cleaner, more sustainable, and prosperous energy future for Spain.

The work we accomplished in 2024 has equipped us to face the current challenges. Now, with the experience we've gained and the lessons we have learned, we are continuing to strengthen the leadership of photovoltaic energy in Spain together.

Rafael Benjumea
Chairman of UNEF

FOREWORD

Elisa Carbonell Martín

Chief Executive Officer
ICEX Spain Trade & Investment

Access to clean and affordable energy is one of the fundamental goals promoted by the United Nations within its Sustainable Development Agenda. There is no doubt that this is a strategic objective not only at a global level, but also for any country: it improves the competitiveness of companies and industry, contributes to increasing energy independence and security, and facilitates social progress by promoting the development of industry, agriculture, communications, education, health, and transport.

All of this results in greater prosperity for citizens, who benefit from cheaper energy, especially those at risk of energy poverty, and positively impacts the environment, since the consumption of polluting energy remains the main cause of climate change. And it is also a source for economic opportunities for our companies, both at home and abroad, if we get to position ourselves as leaders in this type of technologies.

However, access to clean and affordable energy and the reversal of climate change are not achievements that will be fulfilled by mere inertia. Progressing towards these goals is a conscious, ethical, and politically responsible choice that, as members of the global community, we are obliged to make for the benefit of today's citizens and future generations.

A key factor in meeting this goal is the need for a high level of investment, both in developing countries, where needs are more pressing, and in developed economies, which play a fundamental role in leading global progress. Public and private investment is the engine of sustainable development. Without investment, sustainable development remains an empty promise without substance.

Our country is taking on this challenge: In recent years, Spain has addressed an intense green transition agenda, which is consolidating as a solid lever for the modernization of the Spanish economy. Since 2019, our country has a Strategic Energy and Climate Framework and an Integrated National Energy and Climate Plan (PNIEC), strategic orientation tools that integrate energy and climate policy with a horizon to 2030.

The implementation of the public policies included in the PNIEC and the excellence of Spanish companies, which are world leaders in the sector, are allowing Spain to be at the global forefront in energy transition. In fact, in just five years, renewables have gone from generating 40% to 56% of Spain's electricity mix.

The renewable transformation in our country is therefore a fact to which foreign investment have been instrumental. According to FDI Markets figures from the Financial Times Group, in the last five years Spain has been, after the United States, the second country to receive the most foreign-origin greenfield projects in the renewable energy sector. The 327 projects launched in this sector during that period have resulted in more than 50 billion euros in investments and the creation of more than 23,000 jobs.

Photovoltaic energy plays a leading role in this renewable transformation, as everyone can see in the present 2025 annual report by the Unión Española Fotovoltaica (UNEF), to which ICEX-Invest in Spain collaborates once again. Among other significant figures, it shows that the sector's total economic impact in Spain reached 15.317 billion euros in 2024, creating employment for around 147,000 workers.

But the importance of the Spanish photovoltaic industry is measured not only quantitatively, but also qualitatively, given its role in clean energy supply: in 2024, photovoltaic energy led the Spanish energy mix for the first time in history and did so for four consecutive months. Another noteworthy fact is that, in 2024, Spain reached 40,294 MW of cumulative photovoltaic capacity, consolidating the photovoltaic industry as the renewable technology with the highest installed capacity.

However, further progress must be made, and investment must continue to flow into the photovoltaic industry, so that Spain becomes an alternative for producing, within our country, the equipment and components required by companies in the sector, and so that Spanish companies can increase their research efforts. Today's R&D will make us protagonists of tomorrow's photovoltaic industry.

That is why ICEX Spain Export and Investments, which has a determined commitment to sustainability at the environmental, social, and governance levels, has collaborated in the preparation and English edition of this report prepared by UNEF, the reference association for the photovoltaic sector in Spain, to put it on the radar of potential foreign investors interested in the Spanish photovoltaic sector in order to encourage them to consider business opportunities in our country.

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IN 2024, GLOBAL PHOTOVOLTAIC CAPACITY INCREASED BY 35% COMPARED TO 2023.

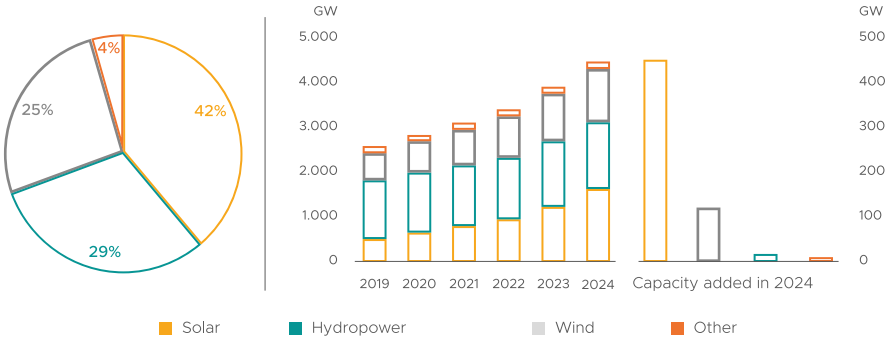
International

In 2024, photovoltaic energy reaffirmed its status as the world's fastest-growing renewable technology. According to the International Energy Agency's (IEA) PVPS programme, **602 GWp of new photovoltaic capacity was installed, bringing the global total to 2,246 Gwp**. This marks a 35% increase in annual installed capacity compared to 2023.

Photovoltaics accounted for **75% of newly installed renewable capacity and generated 60% of the total renewable energy**. China maintained its leading position with 357.3 GWp installed, representing over 52% of the global total, followed by the European Union with 62.6 GWp and the United States with 47.1 GWp. **India** has significantly accelerated its renewable energy deployment, adding 31.9 GWp over the past year. **Spain** has secured its place among the top 10 photovoltaic markets worldwide

International growth forecasts are largely driven by Asian countries like China, India, and Pakistan. Despite this growth, the sector faces challenges, including China's **industrial overcapacity**, **trade tensions** due to the tariff war, and pressure on margins as countries **develop domestic industries**. These issues are prompting the adoption of protectionist measures and the diversification of supply chains.

Figure 1: Generation capacity and capacity growth by energy source



Source: IRENA: Renewable capacity highlights

Europe

In 2024, the **European Union surpassed 65.3 GWp** of new photovoltaic capacity for the first time. However, **year-on-year growth slowed to 4.4%**, a marked difference from the over 40% increase seen in 2022-2023. Germany was the frontrunner with 17.4 GWp, followed by Spain with 7.2 GWp and Italy with 4.2 Gwp. The slowdown is attributed to **negative price** trends, stabilisation of average electricity prices, and the **depletion of incentives for self-consumption**.

Key regulatory developments include the implementation of the **RED III Directive**, which sets a binding target of 42.5% renewables by 2030, and the approval of the **Net-Zero Industry Act**, aiming for 40% domestic manufacturing of strategic technologies by 2030. There are also **new targets for 2040**, including a 90% reduction in net greenhouse gas emissions compared to 1990 levels. Other important measures are the **Solar Roof Standard**, becoming progressively mandatory from 2027, the **Nature Restoration Act, and Nature Credits**. The reform of the European electricity market, effective since July 2024, enhances price stability by increasing the use of power purchase agreements (PPAs), long-term contracts, and flexibility mechanisms, including storage.

Forecasts for 2025 suggest a slowdown in the European solar market. According to the medium scenario by SolarPower Europe, **the EU is projected to reach a cumulative capacity of around 890 GW by 2030**, which falls short of the expectations set in previous years.

SPAIN BECAME THE SECOND LARGEST PHOTOVOLTAIC MARKET IN EUROPE, FOLLOWING GERMANY.

Spain

Spain's total cumulative photovoltaic capacity reached 40,294 MW, reinforcing its leading position in the renewable energy mix. **Ground-mounted solar plants maintained a steady pace** with 6,039 MW installed, a slight decrease of 1.47% compared to 2023. However, self-consumption dropped by 31%, with only 1,182 MW installed in 2024. This decline indicates the end of the rapid expansion cycle and underscores the need for new measures to revitalise this segment.

The pace of **economic electrification** is slow, which limits the capacity to integrate additional renewable electricity generation. **Between 2019 and 2024, the share of fossil fuels in final energy consumption decreased by just two percentage points**, from 69% to 67%. Meanwhile, the share of renewables in the electricity sector increased significantly, rising from 38% to 56%.

The **domestic photovoltaic component industry** in Spain continues to be competitive, particularly in inverters, trackers, and

structures. The challenge now is to bolster local manufacturing to enhance resilience against trade tensions.

Economic and social footprint of photovoltaics in Spain

In terms of **economic contribution**, the photovoltaic sector had a **direct impact on GDP**, both internally and externally, amounting to **€4.596 billion in 2024**, which is very similar to its contribution in 2023. The **total economic footprint of the sector**, including the combined effects of direct, indirect, and induced GDP generation within and outside the national economy, **was €15.317 billion in 2024**, marking a 2% decrease compared to the previous year.

PHOTOVOLTAICS CONTRIBUTED OVER 270 MILLION TO LOCAL FINANCES.

From an **employment** perspective, the total impact in Spain amounted to 146,764 workers connected to the photovoltaic sector in 2024, including **35,105 in direct jobs**, 75,569 in indirect roles, and 36,090 in induced employment.

The trend of **negative prices** in the electricity market that was seen in 2023 continued into 2024. Electrifying demand and deploying storage are emerging as key tools for stabilising prices, enhancing grid reliability, and reducing fossil fuel use. However, progress in these areas is slower than needed to achieve the planned targets.

Storage and Renewable Hydrogen in Spain

Storage is becoming crucial, with cumulative capacity behind the meter reaching 2,205 MWh since 2022, although **only 327 MWh was installed in 2024, marking a 34% decline**. Large-scale deployment is slowed by administrative barriers and a lack of a clear regulatory framework, despite **applications with access permits exceeding 9.5 GW**.

Spain is solidifying its position as a leading force in **green hydrogen in Europe, adding 2,600 km to its network in 2024, which accounts for 12% of the European total**, and participating in the H2Med corridor. Seven major projects have been approved under the IPCEI Hy2Use, with 652 MW of electrolysis capacity. Currently, 361 projects have been identified, 167 of which are commercial, offering a total potential capacity of 23 GW.

ADDITIONALLY, 327 MWH OF NEW BEHIND-THE-METER STORAGE WAS INSTALLED IN 2024.

Self-consumption and energy communities in Spain

In 2024, **self-consumption** added **1,182 MW** of new capacity, marking a **31%** drop compared to 2023's **1,706 MW** and a 53% decline from the 2022 record of **2,507 MW**. This decrease, driven by stabilising electricity prices, higher financing costs, and eco-

nomic uncertainty, is **moving us further from the trajectory needed to meet the National Integrated Energy and Climate Plan (PNIEC) target of 19 GW by 2030**. By the end of 2024, cumulative self-consumption capacity was noticeably below the anticipated path. This shortfall underscores the need to strengthen promotion policies, simplify procedures, and enhance integration with storage and collective self-consumption.

Energy communities, although still in their early stages, have continued to grow and expand geographically. As of 2024, there are **659 identified projects in operation**, up from an estimated 500 in 2023. This expansion is linked to the implementation of European directives, pending regulatory developments, and the establishment of **Community Transformation Offices**, which help with their creation and management.

ALTHOUGH SELF-CONSUMPTION SLOWED, ENERGY COMMUNITIES EXPANDED TO 659 PROJECTS.

Spanish regulatory environment

In 2024, the national regulatory landscape was characterised by the **extension of administrative milestones**, the approval of Royal Decree 662/2024, which established the regulatory framework for floating photovoltaics, and progress in several autonomous communities regarding **administrative simplification, self-consumption, and storage**. However, regulatory tensions remain in certain areas due to new **taxes** or **restrictions** that could impede the development of new projects.

Order TED/353/2024 brought adjustments to the **RECORE** regime by revising the VADPM calculation methodology to prevent distortions. In the area of taxation and energy, **Royal Decree-Law 10/2024**, which aimed to introduce a temporary tax on energy operators in 2025, was repealed after it failed to gain parliamentary approval. Similarly, **Royal Decree-Law 7/2025**, intended to implement urgent measures for integrating renewables into the grid and enhancing storage development, also did not pass through parliament. However, its provisions are being transformed into a Royal Decree, which is currently undergoing public consultation at the time of writing this report.

In 2024, one key development was the opening of a **public consultation on the new Royal Decree on Self-Consumption**, aiming to update the existing **RD 244/2019** framework. The proposed measures focus on simplifying procedures, making the distribution of surpluses more flexible, and developing the role of the self-consumption manager. Moreover, the **CNMC** approved **Circular 1/2024**, which set the methodology and conditions for the access and connection of demand facilities, incorporating criteria to streamline

RDL 7/2025, DESIGNED TO INTEGRATE RENEWABLES AND ENHANCE STORAGE, HAS NOT YET BEEN RATIFIED AND REMAINS UNDER CONSIDERATION AS A ROYAL DECREE.

processes and enhance transparency. Meanwhile, several autonomous communities introduced their own regulations to promote renewables, self-consumption, and storage. However, in some instances, these regulations included limitations that could slow down project implementation.

UNEF in 2024 - 2025

UNEF has bolstered its institutional influence by participating in over 80 key meetings and making proposals that have been incorporated into regulations like RDL 7/2025. **Internationally**, it has represented Spain in organisations such as the IEA PVPS, IRENA, Global Solar Council, and SolarPower Europe. The association has introduced the **Seal of Excellence in Storage** and continued to expand the Seal of Excellence in Sustainability.

UNEF has also promoted **sector-specific conferences**, addressing critical topics like sustainability, storage, energy communities, agrovoltaics, and self-consumption. Additionally, it organised the 11th Solar Forum, the sector's main event, which attracted 1,100 attendees.

The sector is entering 2025 with a strong foundation of installed capacity, an extensive project portfolio, and established leadership on the international stage. The **immediate challenge is to speed up the deployment of storage solutions, reignite the momentum of self-consumption, bolster the national industry, and advance demand electrification**. These steps are crucial to reinforce the role of photovoltaics as the cornerstone of the energy transition, an economic driver, and a safeguard of energy sovereignty. The market outlook will **depend on how market prices evolve and whether administrative milestones are met**, both of which directly impact the feasibility of projects and the dynamics of renewable energy auctions. Nevertheless, there is a significant number of projects undergoing administrative processing, which presents considerable potential for sustained growth in the coming years.

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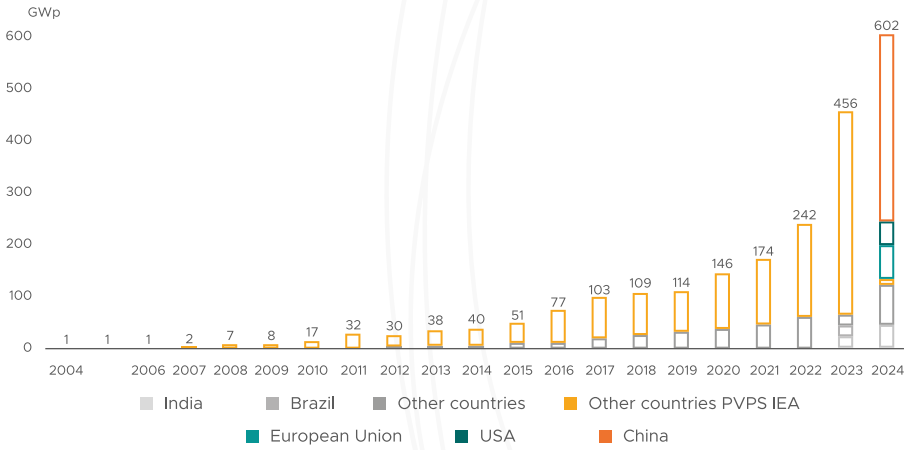
1 | INTERNATIONAL FRAMEWORK

1.1. THE GLOBAL PHOTOVOLTAIC SECTOR

In 2024, the deployment of photovoltaics worldwide continued its significant growth, driven by the inherent competitiveness of this technology. Even with declining prices for both electricity and solar modules, photovoltaic generation still managed to offer lower costs than the average market prices, which increased its penetration in electricity systems. According to the International Energy Agency's (IEA) PVPS programme, in which UNEF serves as the sector representative for Spain, **602 GWp of new solar capacity was installed** globally. This sets a new annual record and reinforces the leadership of photovoltaics within the renewable energy sector. In 2024, **photovoltaics accounted for 75% of new renewable capacity** and 60% of renewable generation, maintaining the levels seen in 2023.

IN 2024, 602 GWP OF NEW PHOTOVOLTAIC CAPACITY WAS INSTALLED GLOBALLY, BRINGING THE TOTAL TO 2,246 GWP.

Figure 2: Trend in installed renewable capacity, 2004-2024.



Source: International Energy Agency, PVPS Programme

In 2024, **installed photovoltaic capacity** saw widespread growth, reshaping the rankings of countries with the highest annual deployment. China once again led the field with 357.3 GWp installed, accounting for more than 52% of its total capacity and more than double the previous year's amount.

The **European Union** continues to be the second most significant player in terms of installed capacity, reaching 62.6 GWp, which marks a 12% increase from the previous year. This year, the **United States** secured third place with 47.1 GWp, pushing **India** to fourth place with 31.9 GWp of annual installations.

Completing the list of the top ten countries with the most photovoltaic installations worldwide are Pakistan (17 GWp), Germany (16.7 GWp), Brazil (14.3 GWp), Spain (7.5 GWp), Italy (6.6 GWp), France (5.9 GWp), and Japan (5.5 GWp).

Figure 3: Top 10 countries by highest annual (left) and cumulative (right) PV installed capacity

ANNUAL INSTALLED CAPACITY				ACCUMULATED CAPACITY			
1		China	357.3 GW	1		China	1,048.5 GW
(2)		European Union*	62.6 GW	(2)		European Union*	339.4 GW
3		USA	47.1 GW	2		USA	224.1 GW
3		India	31.9 GW	3		India	124.6 GW
4		Pakistan	17.0 GW	4		Germany	99.8 GW
5		Germany	16.7 GW	5		Japan	96.9 GW
6		Brazil	14.3 GW	6		Brazil	52.1 GW
7		Spain	7.5 GW	7		Spain	47.2 GW
8		Poland	6.6 GW	8		Australia	38.6 GW
9		Italy	5.9 GW	9		Italy	37.0 GW
10		Japan	5.5 GW	10		Korea	31.7 GW

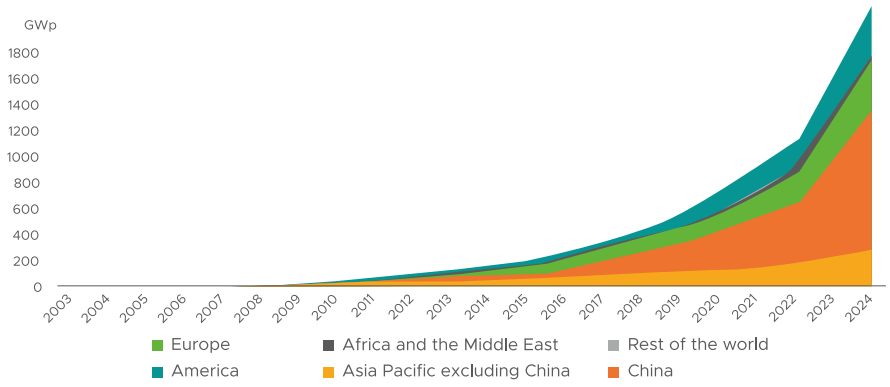
Source: International Energy Agency, PVPS Programme

SPAIN CONTINUES TO RANK AMONG THE TOP 10 COUNTRIES IN THE WORLD FOR BOTH INSTALLED AND CUMULATIVE CAPACITY IN 2024.

For the first time, global cumulative photovoltaic capacity has surpassed **2.25 Twp**. China has cemented its position as the world leader, with 1,048.5 GWp, followed by the European Union with 339.4 GWp and the United States at 224.1 Gwp. India has climbed to fourth place with 124.6 GWp, while Germany (99.8 GWp) and Japan (96.9 GWp) complete the top five.

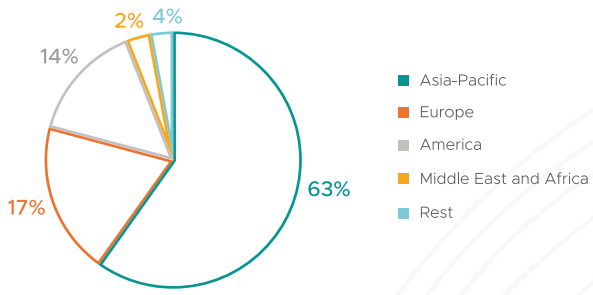
The regional distribution of **cumulative photovoltaic capacity** remained stable in 2024. The Asia-Pacific region leads with nearly 63% of the global total, driven primarily by China, along with significant growth in India and Pakistan. Europe holds the second spot with 17%, down two percentage points from the previous year, bolstered by established markets like Germany, Spain, Italy, and France. Meanwhile, the Americas account for 14% of global capacity.

Figure 4: Regional trends in cumulative PV capacity.



Source: International Energy Agency, PVPS Programme

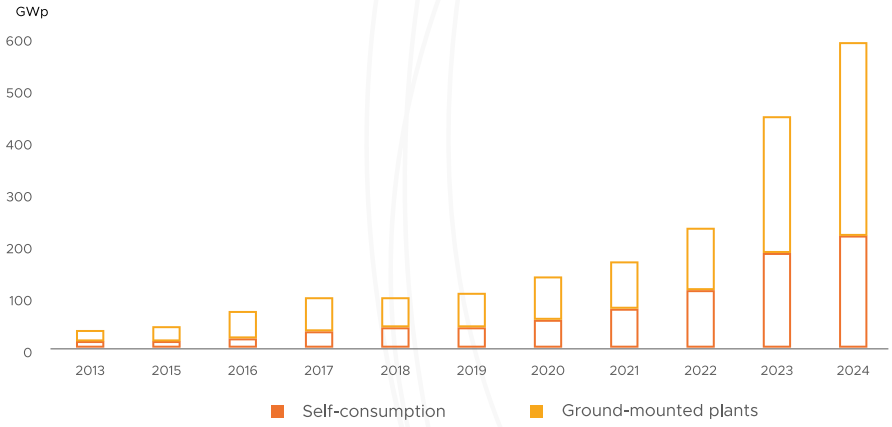
Figure 5: Regional trends in cumulative PV capacity.



Source: International Energy Agency, PVPS Programme

Regarding **market segments**, while both self-consumption and ground-mounted plants grew in 2024, ground-mounted plants saw a significantly greater increase. Self-consumption made up about one-third of the installed capacity that year, with other emerging applications like agrivoltaics, building-integrated photovoltaics (BIPV), and vehicle-integrated photovoltaics (VIPV) also gaining traction.

Figure 6: Breakdown of annual installed PV capacity, 2011-2023.



Source: International Energy Agency, PVPS Programme

1.2. AUCTIONS AND PPAS

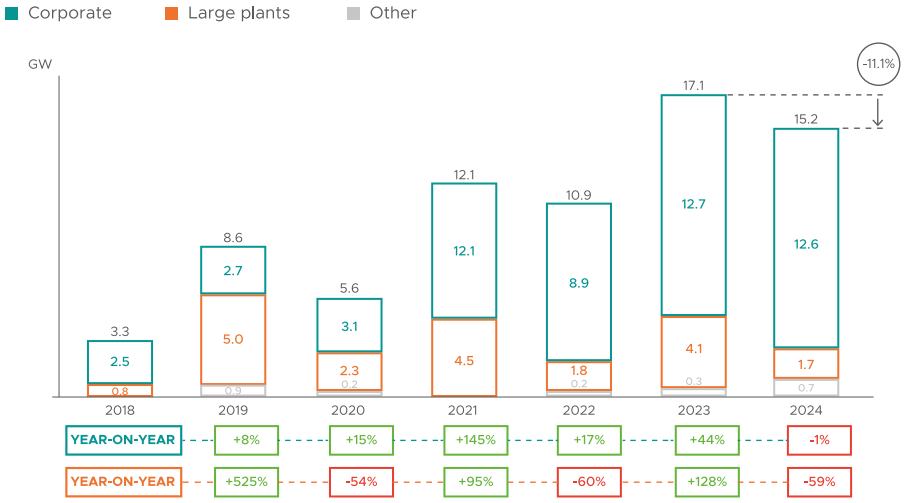
The International Energy Agency's (IEA) Renewables 2024 report indicates that around **110 GW of renewable capacity was awarded through competitive auctions** in 2024, consistent with the record achieved in 2023. However, the growth in auction volume has stabilised following several years of expansion, due to project implementation delays, narrower margins, and a more complex financial environment. Notably, **60% of these auctions included non-economic criteria**, such as sustainability and supply security, which have enhanced the socio-economic value of the awarded projects.

DURING THE SAME YEAR, OVER 110 GW WAS SECURED THROUGH COMPETITIVE AUCTIONS, WITH AN ADDITIONAL 46 GW THROUGH PPA CONTRACTS WORLDWIDE.

The **Asia-Pacific** region once again led in terms of awarded volume, accounting for more than **50% of the global solar PV capacity auctioned**. India reached a new high due to contractual improvements and increased clarity for developers. Meanwhile, **China**, although it reduced the use of formal auctions, maintained significant volumes through quasi-regulated mechanisms. Conversely, countries like **Vietnam, Thailand, and Indonesia** are progressing more slowly due to regulatory and financial barriers. This region has the lowest prices worldwide, but the IEA warns of increasing tension between aggressive bids and the economic viability of projects.

In **Europe**, the PPA market went through a period of adjustment in 2024. According to the Pexapark Renewables Market Outlook 2025, 316 long-term PPA contracts were signed, marking a 14% increase from 2023, although with more moderate volumes: 15.2 GW, which is an 11% decrease year-on-year. This contraction resulted largely from a 59% fall in PPAs with utilities, along with a 38% reduction in the number of agreements. Meanwhile, corporate buyers boosted their activity by 26%, with 157 companies signing their first PPA and contracting around 5.2 GW. Activity benefitted from price stabilisation (ranging from €49 to €52/MWh), but was also influenced by challenges such as more frequent negative price events, intraday volatility, and low capture rates, which heightened risk and led signatories towards more cautious agreements.

Figure 7. Trend of PPAs in Europe by disclosed contracted capacity, 2018-2024 (GW)



Source: Pexapark Renewables Market Outlook 2025.

Spain led once again in PPA volume with **4.66 GW**, a 5.5% year-on-year decline, while **Germany** had the highest number of contracts, with **48 agreements**, marking a 9% increase. Key players included Iberdrola, which contracted 1.25 GW, a rise of 38%, and

Amazon, which signed for over 1.5 GW despite a 20% decrease. By technology, solar dominated with more than 8 GW (-28%), followed by onshore wind (3.1 GW, +25%) and hybrid PPAs, which experienced the highest relative growth (2.75 GW, +219%).

The market diversified geographically and in its contractual structures. Notably, new schemes such as multi-buyer PPAs, storage agreements (PSAs), and the first contracts for green hydrogen projects (407 MW) highlighted the increasing sophistication of the European market.

In **Latin America**, auctions have taken place in Colombia, Argentina, Uruguay, and Brazil. **Colombia** auctioned 1,215 MW of solar power, awarded to six projects through the "Reliability Charge" auction in February 2024. The contractors have secured rates of around $18.20/MWh and are expected to begin operations from 2027. **Uruguay** launched an extraordinary auction in 2024 to add up to 200 MW of new solar capacity, involving 20-year contracts with a price cap of $50/MWh, with awards anticipated in November. **Argentina's** RenMDI 2024 tender has invited bids for 620 MW of renewable projects, part of which is allocated to solar. Over 200 proposals have been submitted, and while the evaluation and award process is ongoing, operations are expected to commence within three years. **Brazil** included solar capacity in its 2024 A-4

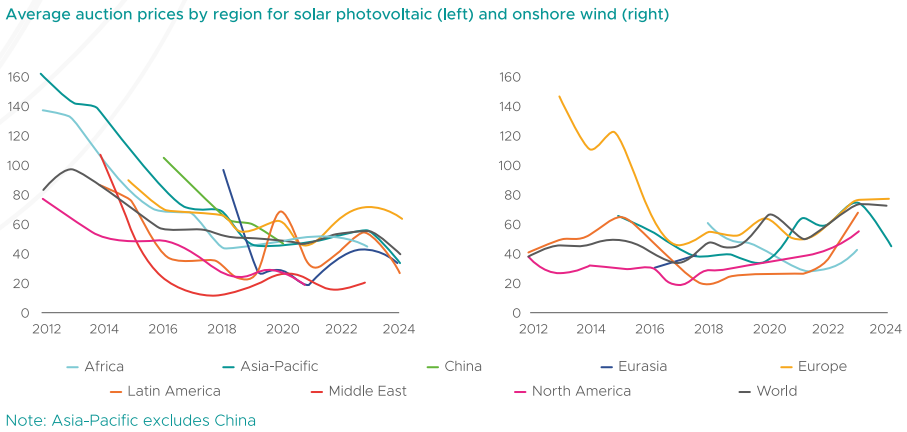
"Les Îlots Blandin (74.3 MWp), comissioned in 2025, is the largest floating solar PV plant in Europe"
© Romain Berthiot

Velto's solar PV plants:
Les Ilots Blandin (France) , San Nicolás (Spain) and Aznalcollar (Spain)

auction, awarding about 237 MW. Although solar participation was limited, the prices for this technology were around $32/Mwh.

In the **Middle East and North Africa**, Israel added approximately 900 MW of solar capacity in 2024, primarily through PPA schemes, securing its position as a regional leader in renewable energy. In December 2024, Saudi Arabia awarded 1.7 GW of solar projects to EDF and TotalEnergies (1.4 GW and 0.3 GW respectively) under 25-year PPA contracts, as part of its strategy to achieve 130 GW of renewable energy by 2030. Meanwhile, Algeria launched a tender for the development of 2,000 MW of solar plants (comprising 15 projects of 80–220 MW each), with construction initiated in 2024 in line with its plan to reach 12 GW of renewable capacity by 2030.

Figure 8. Historical trend of average prices awarded in solar auctions (2012-2024)



Source: International Energy Agency, Renewables 2024.

1.3. DEVELOPMENTS IN COSTS

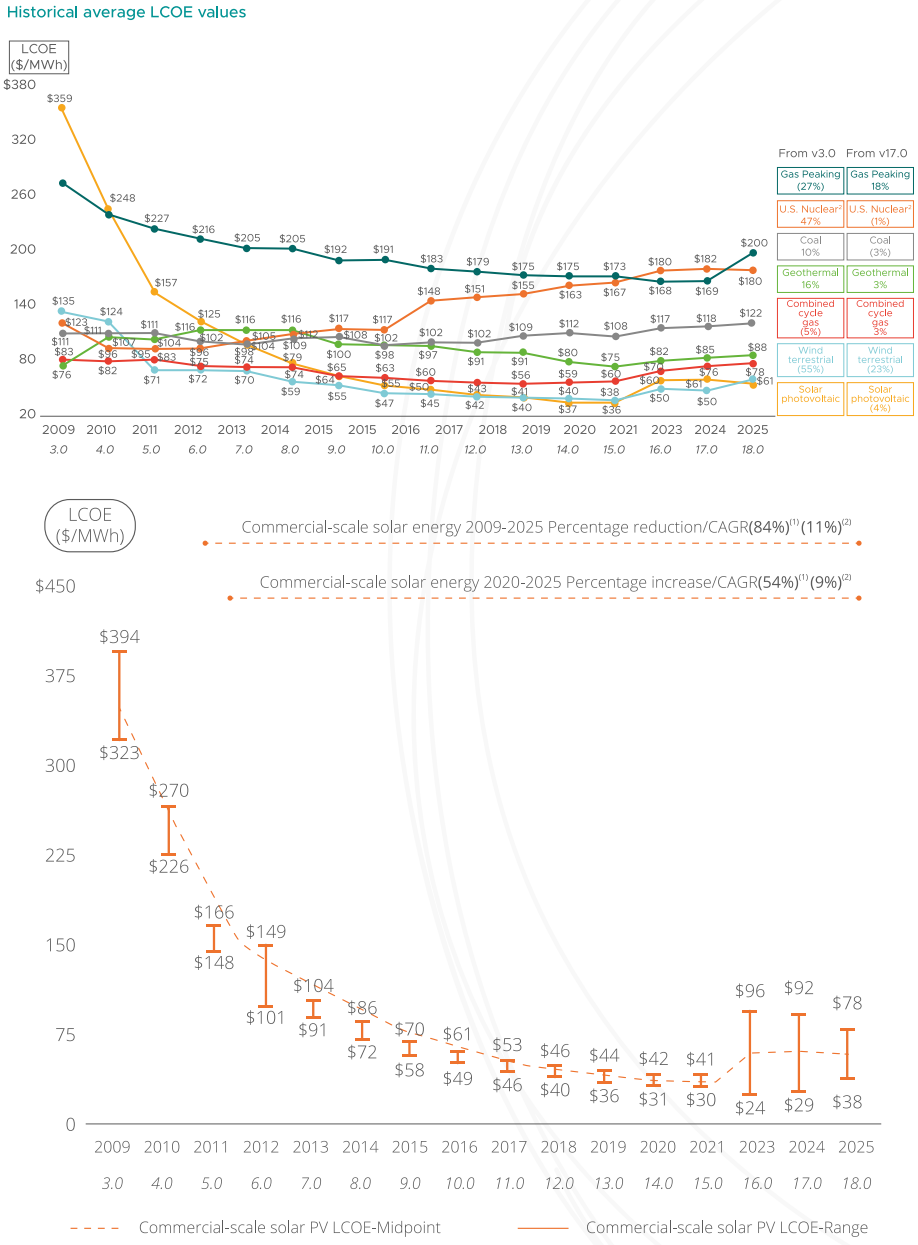
Prices for clean technologies have already hit historic lows, with the **downward trend expected to continue into 2025**. BloombergNEF reports that production costs for photovoltaic modules and batteries could decrease by 5% to 11%, improving upon 2024 figures. However, this trend might be temporarily slowed by increasing industrial overcapacity in China, prompting various countries to implement protectionist measures, such as new tariffs on low-cost imports. Despite these challenges, the medium-term outlook remains positive. The levelised cost of electricity (LCOE) for clean technologies is projected to decrease by 22% to 49% by 2035.

According to BloombergNEF's Levelized Cost of Electricity report, the average cost of a fixed-structure solar photovoltaic plant de-

creased by 21% globally in 2024. Although China is selling below its production costs, prices are expected to keep falling. Battery storage costs also dropped by 20% during 2024, reaching £115/MWh.

THE AVERAGE COST OF A FIXED-STRUCTURE SOLAR PHOTO-VOLTAIC PLANT DECREASED BY 21% GLOBALLY IN 2024.

Figure 9 and 10. Comparison of the Levelized Cost of Energy — Historical trend in LCOE



Source: LAZARD, Levelized cost of energy+ June 2025.

China's share of global photovoltaic panel production fell from 84.6% in 2023 to 80% in 2024, partly due to manufacturing incentives in other countries. While the United States and India have also increased their manufacturing capacity, China's production growth has been considerably faster than that of its competitors.

According to PVinsights, **photovoltaic module prices** showed little volatility in April 2025, remaining stable or slightly declining. In response, major manufacturers have started cutting production by reducing orders to original equipment manufacturers (OEMs), while small and medium-sized producers have chosen to clear out their inventories by offering lower prices.

In 2024, photovoltaic module prices hit rock bottom, reaching historic lows in Europe. By April, PERC modules were priced at around €0.10/W. TOPCon modules showed significant regional price differences: in the United States, they reached €0.24/W in December, whereas in China, during the second half of 2024, prices ranged between €0.079 and €0.083/W.

The **cost reductions** in 2024 and 2025 are also attributed to two factors: the **decreased use of silver**, which is crucial for the electrical contacts of the cells, **and the standardisation of rectangular wafers** in solar panels. In 2024, the photovoltaic sector accounted for 20% of global silver consumption. One emerging cost-reduction strategy involves partially replacing silver with silver-coated copper, which maintains electrical conductivity while reducing reliance on this expensive material.

In 2024, N-type cell technologies, accounting for 71.1% of the Chinese market, required more silver than P-type cells, which had a 20.5% market share. Leading Tier 1 manufacturers report the following average consumption per technology:

LOOKING AHEAD TO 2025, EFFORTS ARE FOCUSED ON REDUCING THE COST OF PHOTOVOLTAIC MODULES BY DECREASING THE USE OF SILVER AND STANDARDISING WAFERS.

PERC: 7-8 mg/W

TOPCon: 12-16 mg/W

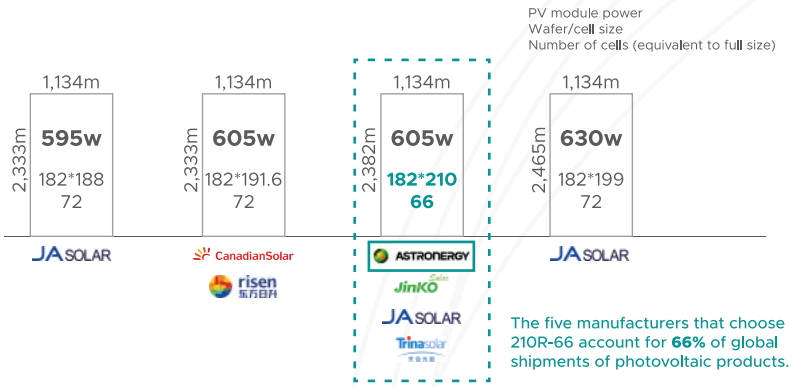
HJT: 17-20 mg/W

Since late 2023, major manufacturers have widely adopted 210R-type **rectangular wafers** (182 × 210 mm), particularly for large-scale plants. Five manufacturers are already using this format, equivalent to full-size 66-cell modules, which optimises the active area. These wafers are also used in smaller formats (48 and 54 cells) for residential self-consumption. The width of the short side has been standardised at 1,134 mm, simplifying design and logistics.

The conclusion of the regulatory review of demand in China has had a direct **impact on polysilicon prices**. Concerns about market trends from June 2025 have prompted caution in commercial

operations. The Chinese industry continues to implement production control measures, with the main manufacturers operating at an average capacity factor of 42.34%. In April 2025, polysilicon production reached 99,100 tonnes but is expected to decrease to around 96,000 tonnes in May due to scheduled maintenance at several plants.

Figure 11: Rectangular wafers adopted by leading manufacturers.



Source: IEA PVPS 2025 / Astronergy (Chint Group).

In April 2025, following the earthquake in Myanmar in March, **photovoltaic wafer prices** temporarily rose. However, the completion of the installation cycle in China has brought the issue of oversupply back to the forefront. Some small and medium-sized manufacturers are offering discounts to clear their accumulated stock With demand weakening, a reduction in production is anticipated in May.

Prices for crystalline silicon solar cells increased in March 2025 but began to decline in April. With uncertainty surrounding future demand, major manufacturers have announced production cuts. If the market contraction continues, many small and medium-sized producers may gradually be pushed out of the market.

1.4. OUTLOOK

In 2024, the global photovoltaic landscape has reinforced some underlying trends while revealing new risks and tensions that will shape the sector in the coming years. Although the production costs of modules and batteries continue to decrease, the rate of decline may slow due to structural overcapacity in China, expanding protectionist measures, and temporary imbalances between supply and demand.

In the medium term, **projections are still positive**: the levelised cost of electricity (LCOE) for clean technologies is expected to decrease by 22% to 49% by 2035, making photovoltaics more com-

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petitive than other sources.

This will be driven by **anticipated growth in electricity demand** due to the electrification of activities traditionally reliant on fossil fuels, such as electric vehicles and heat pumps. BloombergNEF estimates that global data centres will further boost electricity demand.

However, increasing **pressure on margins and high exposure to the risk of negative prices** are challenging the design of power purchase agreements (PPAs) and auctions. In this scenario, we can expect continued progress towards more sophisticated contract structures that include risk management clauses, flexible compensation, and hybrid schemes with storage or combined technologies. The rise of corporate and multi-buyer PPAs will persist, particularly in Europe and America, with new players and aggregation platforms gradually entering the market.

Meanwhile, the reduction in silver usage and the standardisation of rectangular wafers reflect the industry's technological advances. These changes have implications for both material consumption, affecting the supply chain, and module design. The challenge will be to balance innovation with the need to maintain the financial stability of manufacturers, especially amid industrial concentration and fierce competition.

From a geopolitical perspective, there will be continued momentum in **policies aimed at partially relocating manufacturing**, such as the IRA in the United States, the PLI programme in India, and the NZIA in Europe. Although these strategies are still in the early stages, they have the potential to reshape the industry's landscape if they succeed in attracting private investment and creating competitive market volume.

While China, India, the EU, and the US will remain leaders in global growth for installed capacity, a more widespread expansion is expected in emerging regions. Latin America, the Middle East, and North Africa have started to establish competitive auction mechanisms and PPAs, but still face regulatory and financial hurdles. The challenge will be to accelerate their integration by ensuring bankability, regulatory stability, and access to financing for large-scale projects.

2 | EUROPEAN FRAMEWORK

2.1. THE PHOTOVOLTAIC SECTOR IN THE EUROPEAN UNION

In 2024, the EU set a new record for annual installed capacity, surpassing 65.3 GWp of photovoltaic solar energy for the first time. Although year-on-year growth was slower than in the 2022-2023 period, which experienced an increase of between 41% and 53%, there was still a 4.4% rise compared to 2023. This slowdown is attributed to price stabilisation and the end of subsidies for self-consumption following the depletion of NextGen funds.

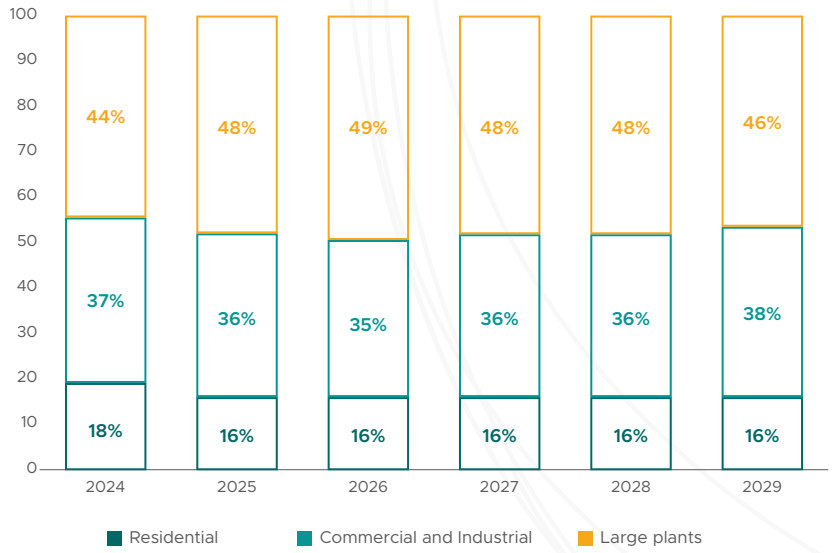
IN 2024, EUROPE INSTALLED 65.3 MW OF NEW PHOTOVOLTAIC CAPACITY,

In terms of segments, **residential self-consumption** faced challenges in many European markets. In 2024, residential self-consumption installations in Europe reached 12.5 GWp, similar to the 2022 total, and **accounted for 19% of all installations**. This represents a decline of about 5 GWp compared to the previous year, or a 9 percentage point decrease from the previous year.

MARKING A 4.4% INCREASE FROM 2023.

Meanwhile, **industrial and commercial self-consumption** has seen slight growth, primarily driven by industrial installations in Germany, Greece, and Italy. This segment made up 37% of total installations in 2024.

Figure 12: EU PV segmentation, 2024-2029



Source: SolarPower Europe

Ground-mounted installations had the largest market share, comprising 44% of the total installed capacity in the European photovoltaic market.

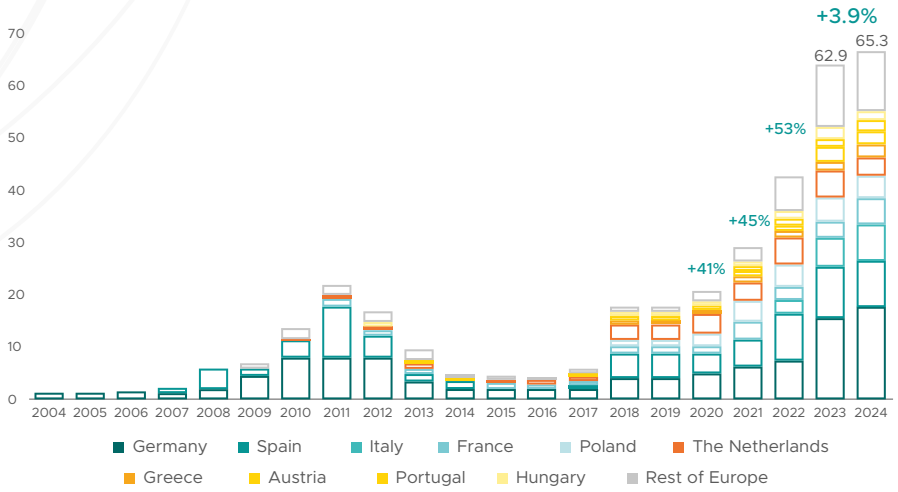
SPAIN REMAINS THE SECOND-FASTEST GROWING COUNTRY IN EUROPE FOR PHOTOVOLTAIC EXPANSION.

Germany, the world's fifth-largest market, once again led solar growth in Europe, achieving an annual installation of 17.4 GWp, well above its 2024 target of 13 GW. This increase was mainly driven by auctions held throughout the year.

Spain recorded a 7.8% decline in new installed capacity compared to 2023, due to a 1.5% decrease in ground-mounted plants and a 31% drop in the self-consumption segment.

In contrast, Italy increased its annual installations by 27%, marking its best performance in over a decade. Completing the leading group are **France**, with 4.7 GW installed in 2024, and **Poland**, with 4.4 GW.

Figure 13: Total installed capacity EU 2024

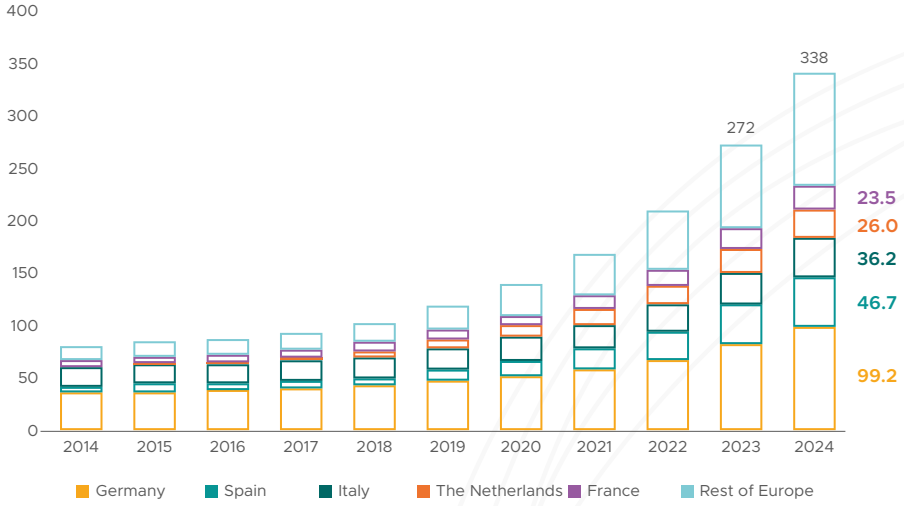


Source: SolarPower Europe

In Spain, installed capacity has grown significantly over the past five years, whereas this expansion across Europe has unfolded over the last decade. European photovoltaic capacity rose from 82 GW in 2014 to 338 GW in 2024.

The **ranking of countries with the highest solar installations** in 2024 have seen little change. Germany remains in the lead with 16.1 GWp, followed by Spain at 7.2 GWp, Italy at 4.2 GWp, and France in fifth position with 4.7 GW. However, in the EU as a whole, only five countries have exceeded the 2023 figures, and they have done so moderately. Notably, France, Greece, and Italy are among those countries.

Figure 14: Total cumulative capacity EU 2024



Source: SolarPower Europe

Since 2021, EU-27 countries have awarded over 51 GW of solar capacity through auctions. Approximately 80% of this capacity is for ground-mounted projects, while rooftop installations account for 10.4 GW. In 2024, there has been a contraction in **solar auctions**, with less than 11 GW awarded compared to nearly 14 GW in 2023, indicating a setback after the partial recovery observed last year. Germany has reinforced its leading position by securing 60% of the allocated capacity, while other countries continue to face issues with underfunding and the withdrawal of schemes.

HOWEVER, THE RATE OF ELECTRIFICATION ACROSS EUROPE HAS LAGGED BEHIND THE PACE OF INSTALLATIONS, MIRRORING THE SITUATION IN SPAIN.

Conversely, the **PPA market** is on the rise; 2024 set a new record with over 7 GW contracted for exclusively solar projects, surpassing the 2023 figures. This growth is fuelled by a diversification of buyers and an increase in multi-technology agreements that integrate solar with wind energy and, increasingly, with storage systems.

SPAIN ALSO CONTINUES TO LEAD EUROPE IN PPA CONTRACTS.

Table 1 year-on-year comparison of auctions and PPAs in Europe

	2023	2024 (YTD)	Change 23-24
Capacity awarded in auctions (EU-27)	~14 GW	<11 GW	**-21%**
Leading country in auctions	Germany (≈40 %)	Germany (≈60 %)	↑ concentration
Number of countries with active auctions	10	6	**-40%**
Signed capacity in solar PPAs	6.3GW	7.6 GW (record)	**5-10 %**
PPA trends	Initial diversification of buyers	Multi-technology growth and expansion in Italy and France	-

Source: SolarPower Europe

2.2. NEW EUROPEAN LEGISLATION

Directive 2023/2413 (RED III)

Directive (EU) 2023/2413 (RED III) has been in effect since November 2023 and must be implemented by May 2025. It raises the EU's binding renewable energy target to 42.5% of gross final consumption by 2030, aiming to potentially reach 45%. This update simplifies permitting procedures through "acceleration zones", sets specific sector targets for transport, heating, and cooling, and includes measures to integrate storage and flexibility into electricity systems. Furthermore, it requires Member States to remove administrative hurdles and accelerate the approval process for renewable projects, thereby strengthening the regulatory framework established by the Fit for 55 package and the REPowerEU plan.

NetZero Industry Act (NZIA)

The **NetZero Industry Act** was approved by the European Parliament and Council in February 2024. Its aim is to promote the European zero-emission technology sector by ensuring that, by **2030, at least 40% of the annual production capacity for strategic technologies** — such as solar panels, batteries, and hydrogen — will be manufactured within the EU.

Figure 15: NZIA roadmap

Source: Own analysis

The agreement sets specific administrative deadlines: projects exceeding 1 GW must obtain construction permits **within 18 months**, while those under 1 GW must do so within 12 months. It also supports the establishment of **zero-emission industrial clusters**, backs carbon capture and storage with a target of **50 million tonnes of CO_2 by 2030**, and encourages local manufacturing within the photovoltaic value chain. The plan includes criteria for sustainability and resilience in public procurement and auction eligibility, requiring at least **30% (6 GW)** of capacity to meet these standards. This includes requirements such as a minimum of **50% of components manufactured in the EU**, responsible business practices, cybersecurity, energy integration, innovation, and environmental sustainability.

European Solar Charter

In April 2024, 23 EU Member States endorsed the European Solar Charter, a joint declaration that outlines a series of voluntary commitments to strengthen the solar energy value chain in Europe. One key initiative is the introduction of auctions designed to enhance industrial resilience, serving as an early tool to boost demand for photovoltaic manufacturing across the continent. Several countries have already implemented concrete measures in line with this commitment: France with its Pacte solaire declaration, Spain through the PERTE renewable energy programme, Italy via the Piano Transizione 5.0 tax scheme, and Austria with the resilience bonus incentive.

Rooftop Solar Standard

On 8 May 2024, the EU Energy **Performance of Buildings Directive (EPBD)** was officially implemented and published in the Official Journal of the European Union. Member States have been given **two years to transpose it** into their national legislation. A key measure within this directive is the **Solar Rooftop Standard**, which mandates the installation of solar systems in new public and non-residential buildings starting in **2027**, in existing non-residential buildings undergoing major renovations from **2028**, and in new residential buildings from **2030**. This directive is a crucial element of the **REPowerEU** strategy, which aims to accelerate the energy transition and reduce reliance on fossil fuels.

FROM 2027, NEW PUBLIC AND NON-RESIDENTIAL BUILDINGS WILL BE REQUIRED TO INCLUDE SOLAR INSTALLATIONS, WITH RESIDENTIAL BUILDINGS FOLLOWING SUIT FROM 2030.

Critical Raw Materials Act

In May 2024, the European Union approved the Critical Raw Materials Act, a regulation designed to enhance access to critical materials essential for the energy and digital transitions. Its purpose is to ensure a stable, sustainable, and diversified supply, enabling Europe to meet its climate and technological targets by 2030.

The regulation outlines specific milestones to bolster the European value chain for strategic raw materials, such as:

- meeting at least 10% of annual consumption through domestic extraction,
- achieving 40% through processing capacities within the EU,
- ensuring that 25% comes from recycling,
- avoiding reliance on over 65% from any single non-EU country.

The regulation also introduces the concept of Strategic Projects, which aims to promote initiatives in extraction, processing, and recycling. The first call for proposals closed on 22 August 2024, attracting significant interest: 170 proposals were submitted, with 121 projects located within Europe.

Corporate Sustainability Due Diligence Directive

In July 2024, the Corporate Sustainability Due Diligence Directive (CSDDD) was adopted. It obliges companies to identify and mitigate negative impacts on human rights and the environment across their entire value chain.

This directive strengthens corporate responsibility not only in their own activities but also in their interactions with suppliers and customers.

Nature Restoration Act

Regulation (EU) 2024/1991, known as the **Nature Restoration Act**, was approved by the Council of the EU on 17 June 2024, published in the Official Journal on **29 July 2024**, and came into effect on **18 August 2024**. The regulation sets legally binding goals to restore at least **20% of the EU's land and marine areas** by 2030 and all ecosystems in need by 2050. Member States are required to submit **national restoration plans** by **1 September 2026**. These plans must include key targets such as restoring at least **30% of degraded habitats** by 2030, increasing this to **60% by 2040** and **90% by 2050**. For freshwater ecosystems, the law mandates actions like reopening at least 25,000 km of rivers, restoring drained peatlands, and planting **3 billion trees** by 2030. The Act aims to reverse ecological degradation, which affects more than 80% of habitats, strengthen ecosystem services, enhance food security, and support the climate and biodiversity goals outlined in the Kunming-Montreal global biodiversity framework.

Electricity Market Design Reform (EMD)

The **reform of the EU's electricity market design** has been in effect since **July 2024**, aiming to enhance the **energy system's resilience**, shield consumers from price volatility, and expedite the integration of renewable energies. This reform was prompted by the heavy reliance of electricity prices on fossil fuels, leading the European Commission to propose a comprehensive review in March 2023. The legislative texts associated with this reform — Regulation (EU) 2024/1747 and Directive (EU) 2024/1711 — came into effect on **16 July 2024**, with Member States required to complete the transposition by **17 January 2025**.

The reform introduces both **fixed and dynamic price** contracts, encourages the use of PPAs, and mandates **Contracts for Difference (CfDs)** for public investments in new renewable capacity. Member States are also required to evaluate their **system flexibility** and take measures such as implementing storage solutions or demand response initiatives. Additionally, the reform enhances transparency regarding grid connection capacity, thereby reinforcing the integration of renewable energy. These efforts contribute to the objective of achieving **45% renewable energy** by 2030, in alignment with the **Fit for 55** package.

Nature Credits

In July 2025, the European Commission introduced the **"Roadmap to Nature Credits"**, an innovative tool aimed at mobilising private investment for actions that protect and restore ecosystems. These credits represent direct investments in initiatives with positive impacts on nature — such as wetland restoration or forest expansion — that can be certified by independent entities, ensuring their credibility. As more than three-quarters of European businesses rely on ecosystem services, nature credits offer a market-based solution to boost biodiversity, generate income for farmers, foresters, fishermen, and local communities, and provide reputational and resilience benefits for businesses and investors.

NATURE CREDITS WILL SERVE AS MARKETS FOR FINANCING ECOLOGICAL RESTORATION THROUGH PRIVATE INVESTMENT.

The roadmap aims to establish clear standards, reliable certifications, and robust governance to prevent greenwashing and close the current ecological financing gap, which is estimated at €65 billion per year. The nature credits will complement public funds, including 10% of the EU budget allocated to biodiversity for 2026–2027. They will be developed through a participatory approach involving businesses, scientists, governments, and civil society. The EU is currently running pilot projects in France, Estonia, and Peru and is working with international alliances such as the Biodiversity Credit Alliance and the World Economic Forum. This initiative is part of the goals outlined in the Nature Restoration Law and the

Kunming-Montreal Global Biodiversity Framework. It aligns with other European strategies, such as the Vision for Agriculture and Food, the Water Resilience Strategy, and the European Pact for the Oceans.

New binding EU targets for 2040

In July 2025, the European Commission proposed an amendment to the **European Climate Law**, aiming for a **binding target for 2040**: reducing **net greenhouse gas emissions by 90%** compared to 1990 levels. This goal is essential in the EU's legal journey towards achieving climate neutrality by 2050. It provides a clear roadmap for the EU from 2030 to 2050, ensuring legal certainty and predictability for investors and companies, while also strengthening industrial competitiveness, energy independence, and economic resilience. This regulatory pathway allows Member States the flexibility to act, prioritising the use of all available measures, such as renewable energy, energy efficiency, carbon capture, and carbon sinks. It also allows for potential flexibility, including the use of high-quality international credits or permanent removals within the ETS from 2036 onwards.

2.3. THE STATE OF THE SOLAR INDUSTRY IN EUROPE

Although installed photovoltaic capacity has seen record growth, Europe's manufacturing industry is **struggling with competitiveness** due to the high prices of imported components, particularly from Asia. The EU **aims to achieve at least 30 GW of solar manufacturing capacity in every segment of the value chain by 2030**. However, manufacturers like Meyer Burger in Germany have announced production cuts because of insufficient support.

In response, **Germany** has implemented measures under the TCTF temporary aid framework, which include resilience auctions offering €55 million in 2024 for projects using domestic panels. **Italy** has strengthened its strategy with Decree-Law No. 181 (enacted in February 2024) and by financing the 3Sun project in Sicily, which aims to achieve 3 GW and has received €560 million from the European Investment Bank (EIB). **France** has introduced a €2.9 billion package of tax credits aimed at boosting the production of panels, batteries, and heat pumps.

Additionally, the EU has allocated nearly €800 million to solar manufacturers in the latest round of the **Innovation Fund**, with beneficiaries including 3Sun, Meyer Burger, and Norsun.

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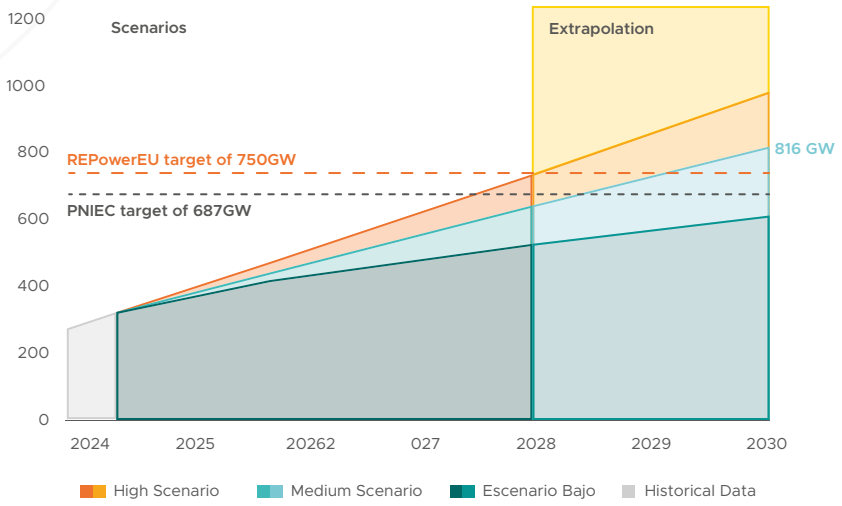
2.4. OUTLOOK

Annual growth in Europe has slowed dramatically, dropping from 53% in 2023 to 4% in 2024. According to SolarPower Europe, the EU is now expected to reach 890 GW by 2030, which is a downgrade from last year's expectations. Contrary to the announcements made in 2023, in the worst-case scenario, the EU might not meet the targets set by the National Integrated Energy and Climate Plans (PNIEC).

SOLARPOWER EUROPE'S AVERAGE SCENARIO SUGGESTS THAT REPOWEREU TARGETS WILL BE ACHIEVED BY 2030.

In 2024, a 35% reduction in the prices of solar modules and components in Europe, coupled with lower balance of system and installation costs, decreased the CAPEX of photovoltaic systems by 2% for rooftops and 28% for ground installations. This led to a 13% decline in capital investment, falling to less than €55 billion, despite a 4% increase in new installations.

Figure 16: Solar market scenarios 2024-2030



Source: SolarPower Europe

By country, in 2024, o**nly 5 out of the 10 largest solar markets in the EU showed growth**, in contrast to the broad increases seen in 2023. France added 1.5 GW, Greece 1.3 GW, Italy 1.1 GW, and Germany 1 GW. Meanwhile, Spain, the Netherlands, Poland, Austria, and Hungary saw decreases. The Netherlands experienced the largest drop, going from 4.9 GW to 3 GW (a decrease of 1.8 GW), due to uncertainty around the phasing out of net metering in 2027. Spain slightly reduced its installation of ground-mounted solar plants, while the self-consumption segment experienced another decline, this time by 31%. Poland's capacity fell by 500 MW due to the transition to net billing and grid issues; Austria saw a reduction of 400 MW in the commercial and industrial segment; and Hungary also faced declines after moving to net billing. **Nonetheless, 16 out of 27 countries each added more than 1 GW in 2024**, setting a new record. Greece rose to 7th place and Portugal to 10th, replacing Sweden and Belgium.

The EU solar market is set to keep growing, albeit at a more moderate pace following the recent boom. In the medium scenario, annual installed capacity is projected to rise from 70 GW in 2025 (a 7% increase) to 72.3 GW in 2026 (up 3%), then to 76.5 GW in 2027 (a 6% rise), and finally to 81.5 GW in 2028 (increasing by 7%). The high and low projections are less extreme than previous forecasts, indicating a loss of political and economic momentum.

Residential self-consumption, which drove the market during the energy crisis, is expected to continue declining due to the stabilisation of electricity prices, the depletion of European funds, and the withdrawal of schemes like net metering. **The commercial and industrial segment is expected to continue growing at a moderate pace**, while large ground-mounted projects are likely to encounter slowdowns due to grid issues, negative pricing, and a lack of flexibility. An emerging sub-segment is plug-in solar systems (less than 800 W), with over 220,000 units installed in Germany in the first half of 2024.

ANNUAL GROWTH IN 2024 WAS 90% LOWER COMPARED TO 2023

Growth is expected to stabilise as a result of grid congestion, sluggish electrification, delays in permitting and land access, and a less favourable political climate in several Member States. For example, Germany experienced 10.5 GWh of renewable energy losses (4% of its generation) in 2023, along with 300 hours of negative pricing. This figure increased to 415 hours in the first ten months of 2024, leading to network management cost overruns exceeding €3 billion.

3 | NATIONAL FRAMEWORK

3.1. THE PHOTOVOLTAIC SECTOR IN SPAIN

In 2024, Spain's cumulative photovoltaic capacity reached **40,294 MW**, encompassing both self-consumption and ground-mounted plants. This achievement solidifies photovoltaics as the renewable technology with the highest installed capacity.

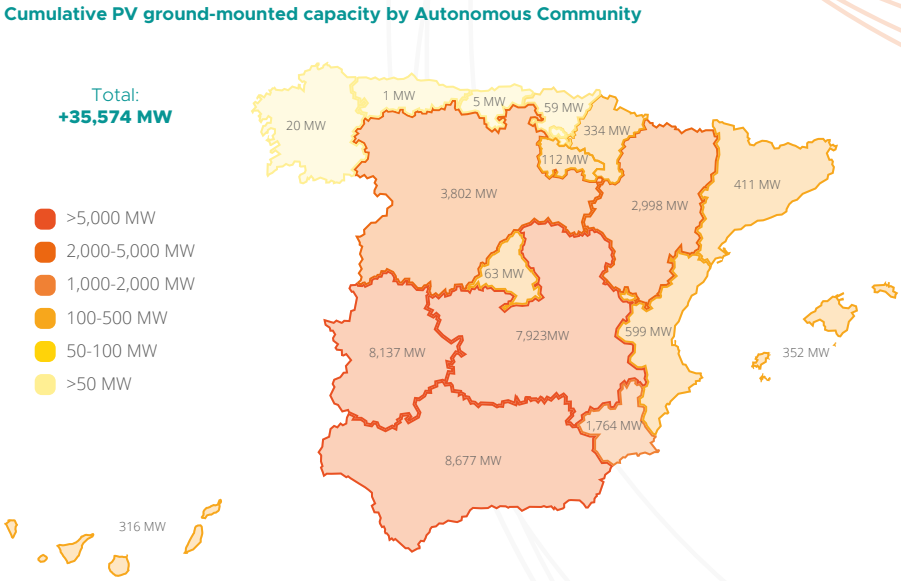
IN 2024, 6,039 MW OF GROUND-MOUNTED PHOTOVOLTAIC PLANTS WERE INSTALLED IN SPAIN

The installation of ground-mounted plants remained steady compared to 2023, with a **minor decrease of 90 MW**, a slight drop of 1.47%. Overall, the pace of installations has been maintained without the need for subsidies or new remuneration schemes.

IN 2024, 1,182 MW OF PHOTOVOLTAIC SELF-CONSUMPTION CAPACITY WAS INSTALLED IN SPAIN

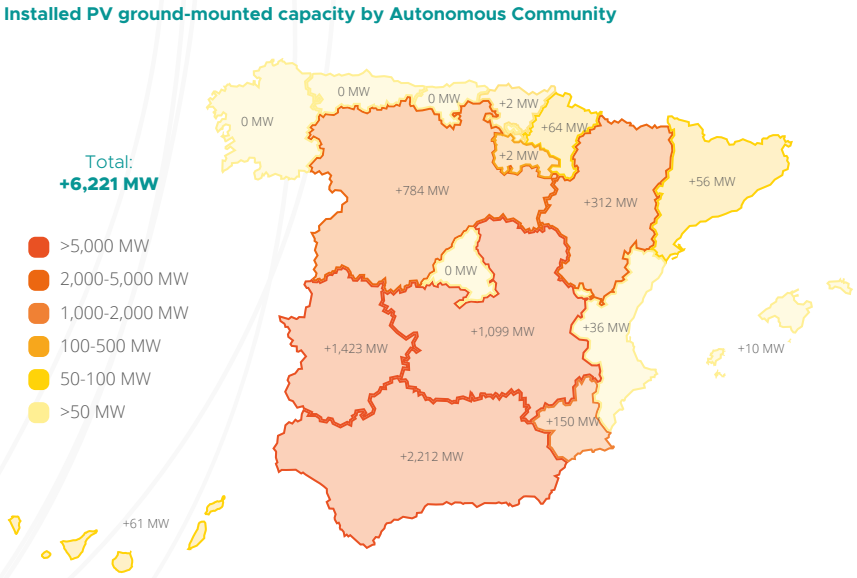
In contrast, **self-consumption saw a 31% decline compared to 2023**, with a total of **1,182 MW installed in 2024**. This trend indicates a contraction in the sector after the strong growth driven by high electricity prices and European subsidies in previous years.

Figure 17: Photovoltaic capacity in ground-mounted plants (including self-consumption as estimated by REE) by Autonomous Community up to August 2025.



Source: Red Eléctrica de España (29/07/2025)

Figure 18. Photovoltaic capacity in ground-mounted plants IN 2024 (including self-consumption as estimated by REE) by Autonomous Community up to August 2025.



Source: Red Eléctrica de España (29/07/2025)

IN 2024, PHOTOVOLTAICS ACCOUNTED FOR 17% OF ELECTRICITY GENERATION

In 2024, photovoltaics made up **17% of the electricity mix**, continuing a trend of steady growth: **6.2% in 2020**, **8.2% in 2021**, **10.2% in 2022** and **14.2% in 2023**, according to Red Eléctrica's data.

3.1.1. Economic footprint

The photovoltaic sector's total economic impact in 2024—including direct, indirect, and induced GDP generated both domestically and internationally—was **€15.317 billion**, a **2% decrease** from 2023 (**€15.637 billion**).

Table 2. Economic footprint (GDP) of the Spanish PV sector. Millions of euros.

	2023	2024p	Growth rate
Direct footprint	4609	4596	0%
Indirect footprint	8218	7844	-5%
Induced footprint	2811	2877	2%
Total footprint	15637	15317	-2%

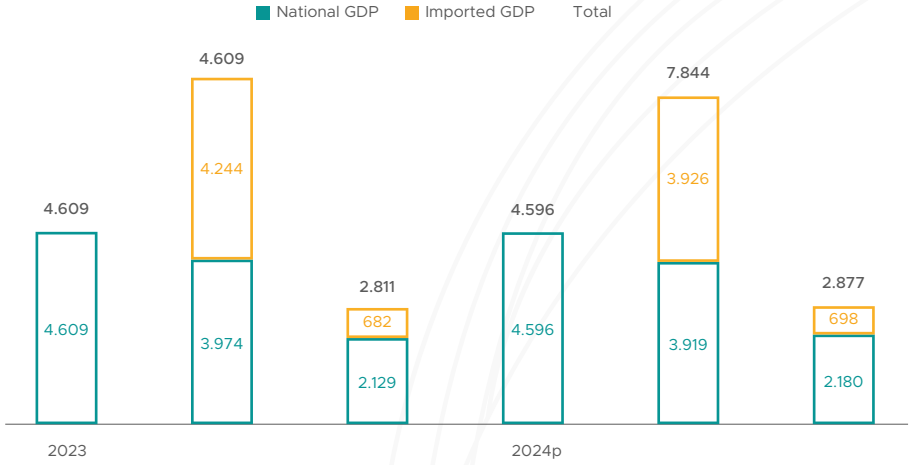
Source: UCLM

IN 2024, THE SECTOR CONTRIBUTED €15.317 BILLION TO TOTAL GDP, BOTH DOMESTICALLY AND INTERNATIONALLY

The **direct** impact on national GDP was **€4.596 billion**, remaining stable compared to the previous year. The indirect effect, stemming from supply chain activities, amounted to **€7.844 billion**, marking a **5% decrease**. This amount was almost evenly split between the national footprint (**€3.919 billion**) and imports (**€3.926 billion**).

Despite the **5%** decline compared to 2023, the **indirect contribution** remained the largest in absolute terms, totalling **€7.844 billion** and encompassing both the impact on national GDP and that generated by imports.

Figure 19. Domestic and imported economic footprint of the Spanish PV sector. Millions of euros.



Source: UCLM

The **induced footprint increased slightly by 2%**, resulting from the additional impact generated by the sector's activity, and was estimated at **€2.877 billion**, of which **€2.180 billion** corresponded to the national economy and **€698 million** to imported GDP.

Table 3. Economic footprint (domestic and imported GDP) by activity group Millions of euros.

2024	Producers	Manufacturers	Engineering and Installers	Mixed + Distributors	Total
Direct footprint	2755	630	835	377	4596
Indirect footprint	2839	1925	1621	1460	7844
Induced footprint	1240	423	848	366	2877
Total footprint	6833	2977	3304	2202	15317

Source: UCLM

In 2024, the breakdown of the sector's **direct contribution** to GDP (both domestic and imported) was led by **energy producers**, contributing **€2.755 billion**, which is nearly **60%** of the total. They were followed by **engineering and installation companies**, which added **€835 million (18.2%)**, and the **manufacturing** sector, contributing **€630 million (13.7%)**. The **mixed category and distributors** accounted for **€377 million**, or **8.2%** of the direct contribution.

The sector's **indirect footprint** reached **€7.844 billion**, with **producers** at the forefront **(€2.839 billion)**, followed by **manufacturers (€1.925 billion)**, **engineering and installation companies (€1.621 billion)**, and the **mixed and distributors category (€1.460 billion)**. The **induced footprint** totalled **€2.877 billion**, highlighting **producers (€1.240 billion)** and engineering and installation companies **(€848 million)**.

In 2024, the Spanish photovoltaic sector reported **exports totalling €3.421 billion** and **imports amounting to €2.037 billion**, resulting in a **total trade surplus of €1.384 billion**, slightly lower than 2023's surplus of **€1.512 billion**. This positive trade balance was mainly driven by the strong performance of **manufacturers**, who exported **€1.784 billion**, **imported €659 million**, and achieved a **trade surplus of €1.125 billion**. **Producers and developers** also contributed, albeit to a lesser extent, with exports of **€1.003 billion**, imports of **€667 million**, and a **surplus of €335 million**. **Engineering firms and installers** exported €233 million and imported €198 million, resulting in **a balance of €34 million**. Meanwhile, the **mixed category and distributors** exported €402 million and imported €513 million, ending with a **deficit of €111 million**. Although export volumes decreased from 2023's figure of **€3.628 billion**, the sector still maintained a **clearly favourable trade balance**, demonstrating its international competitiveness despite the slight year-on-year decline.

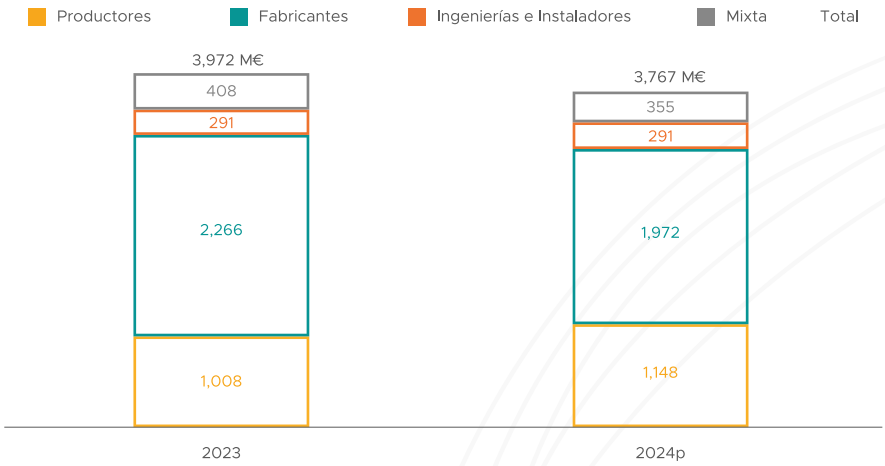
Table 4 Imports, exports by activity. Millions of euros.

		Producers	Manufacturers	Engineers and Installers	Mixed + Distributors	Total
2023	Exports	893	2,043	234	458	3,628
	Imports	559	719	219	616	2116
2024p	Exports	1003	1784	233	402	3421
	Imports	667	659	198	513	2037

Note: Mixed includes Distributors. Producers include Developers. Source: UCLM

When analysing the **total impact of exports in terms of GDP generated by activity**, the photovoltaic sector contributed €3.767 billion in 2024, compared to €3.972 billion in 2023. This calculation **reflects the wealth actually generated in the national economy** from exports, excluding imported content and considering direct, indirect, and induced effects. By segment, manufacturers were the largest contributors (€1.972 billion), followed by producers and developers (€1.148 billion), the mixed category (€355 million), and engineering and installation companies (€291 million).

Figure 20: Total impact of exports in terms of GDP generated by activity.

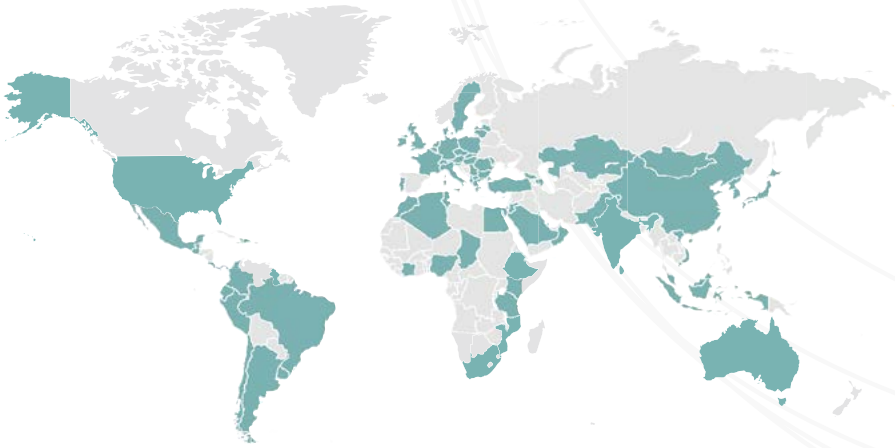


Source: UCLM

The **manufacturing sector** once again led the export impact in terms of GDP, contributing **€1.972 billion**, although this was a decline from **€2.266 billion** the previous year. Producers and developers saw an increase, reaching **€1.148 billion**, while engineering and installation companies kept their contribution steady at **€291 million**. In contrast, the **mixed** category, encompassing distributors and other activities, reduced its contribution to **€355 million**, down from **€408 million** in 2023.

These companies have been identified as operating in more than **59 countries**. As shown in figure 21, besides Europe, businesses in the sector are present across almost the entire American continent, much of Asia, several African countries and Australia. However, since the war in Ukraine, company operations in Asia have decreased due to trade restrictions with Russia.

Figure 21. International presence of Spanish companies in the solar photovoltaic sector. 2024



Source: Prepared by UCLM based on data from SABI, Spanish Ministry of Foreign Affairs and ICEX.

IN 2024, THE ECONOMIC IMPACT OF EXPORTS FROM THE PHOTOVOLTAIC SECTOR WAS €3.767 BILLION

In 2024, the economic impact of exports from the photovoltaic sector was €3.767 billion, in a context marked by the tariff policies and protectionist programmes of the US, India, and China, which had already slowed down growth in 2023.

Table 5. Technological innovation activities: Innovation intensity (%) and R&D&I spending. Millions of euros.

	Innovation intensity (%)	R&D&I spending 2023	R&D&I spending 2024p
Producers	3.04	175	179
Manufacturers	6.73	200	177
Engineering and installers	3.36	93	89
Mixed + Distributors	5.24	80	76
TOTAL 2023	3.87	549	521
TOTAL 2024 (p)	3.78		
TOTAL Spanish companies	1.61		
TOTAL Spanish industry	1.36		

Note: Mixed includes Distributors. Source: UCLM

In the area of R&D&I, companies in the photovoltaic sector allocated **€521 million**, which amounts to an **innovation intensity of 3.78%** of their revenue. Although the overall percentage of expenditure on R&D&I has slightly decreased compared to 2023, it remains more than double the average for Spanish companies **(1.61%)** and well above the national industry average **(1.36%)**.

By segment, **manufacturers** were at the forefront of innovation, with an intensity of **6.73%** and an investment of **€177 million**, followed by **producers** at **3.04%** and €179 million. **Engineering and installation companies** recorded an intensity of 3.36% with €89 million invested, and the **mixed category and distributors** reported **5.24%** with €76 million. Although total investment decreased slightly from €549 million in 2023 to €521 million in 2024, the sector maintained a commitment to innovation well above the national average.

3.1.2. Social footprint

THE SECTOR HAS DIRECTLY EMPLOYED 35,105 PEOPLE NATIONWIDE

The development of photovoltaic energy not only offers environmental and economic benefits but also gives a significant boost to employment in the country. In 2024, the sector employed **146,764 people**, encompassing **direct, indirect, and induced** employment.

Table 6. Employment footprint of the photovoltaic sector by activity. Persons employed

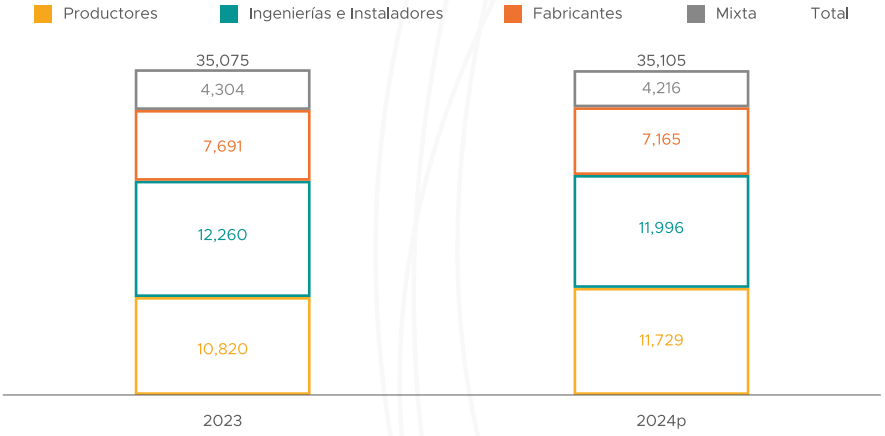
2024p		Producers	Manufacturers	Engineering and Installers	Mixed + Distributors	Total
Direct footprint	Spain	11729	7165	11996	4216	35105

2024p		Producers	Manufacturers	Engineering and Installers	Mixed + Distributors	Total
Indirect footprint	Spain	40052	6767	13466	15284	75569
Induced footprint	Spain	15554	5310	10641	4585	36090
Total domestic footprint		67335	19241	36103	24085	146764

Source: UCLM

The Producers section employed the most people, with a total of 67,335 jobs (including direct, indirect, and induced employment), almost double the number employed by the installers and engineering segment, which reached 36,103 people. **Direct employment remained stable between 2023 and 2024**.

Figure 22 Direct employment by type of activity



Source: UCLM

When analysing the type of activity within the **direct employment** generated, the engineering and installation segment showed the most significant growth. Employing a large number of skilled workers, this segment accounts for 34.2% of total direct employment in Spain. Although this figure decreased by 2% from last year, it still surpasses that of producers, who increased by 8%, rising from 10,820 people to 11,729 in 2024.

Meanwhile, **indirect employment** in the sector contracted by 1%, reaching a total of 75,569 jobs The mixed section, which includes distributors, created the largest number of indirect jobs, accounting for 20.2% of all indirect jobs generated by the photovoltaic sector in Spain.

Finally, the number of **induced jobs** reached 36,090 in Spain, showing a slight increase compared to 2023.

Table 7. Fiscal balance. Millions of euros

	2023	2024p
TAX REVENUE		
National taxes	1586.3	1536.2
Local taxes	238.8	270.4
National insurance contributions	336.6	344.6
Total tax revenue	2161.6	2151.2
TAX BENEFITS		
Investment grants	230.8	177.7
Tax rebates (ICIO and IBI)	17.0	11.8
Total tax benefits	247.8	189.4
TAX BALANCE	1913.9	1961.8

Source: UCLM and data from the State Tax Agency (Agencia Estatal de la Administración Tributaria)

In 2024, the solar photovoltaic sector achieved a **notable fiscal surplus**, with tax revenues reaching **€1.9618 billion**, marking a 2.5% increase compared to 2023. The amounts arising from the **specific remuneration scheme** are not classified as subsidies because they do not originate from the General State Budget but from the sector's own regulations.

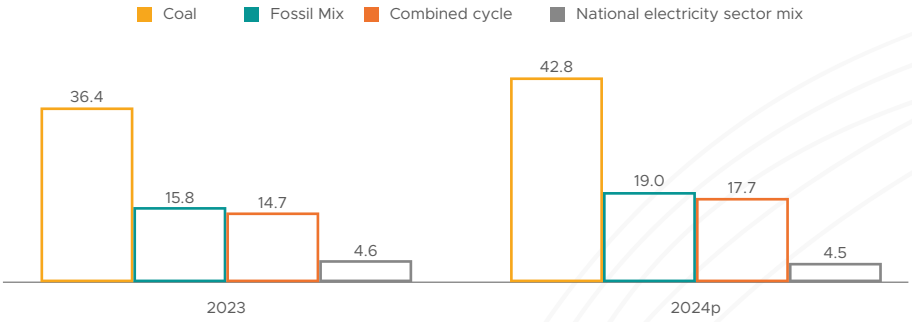
Although **the sector does not receive direct financial aid**, it does benefit from tax incentives provided by autonomous communities and local administrations to encourage self-consumption. These incentives include rebates on **property tax (IBI)** and the **tax on construction, installations, and works (ICIO)**, which support the adoption of photovoltaic installations in residential, commercial, and industrial sectors, and even among energy communities.

3.1.3. Environmental footprint

Renewable energy sources are undoubtedly **the most effective tool for reducing CO_2 emissions**, decreasing reliance on fossil fuels, and driving the decarbonisation of the economy. In this regard, solar photovoltaic energy plays a crucial role by replacing electricity generated from polluting sources, such as gas, in the energy mix, thereby significantly reducing emissions associated with the electricity sector.

Beyond its climate benefits, **the installation of photovoltaic plants can provide opportunities for enhancing biodiversity**. The limited human presence and lack of agrochemicals in these areas contribute to improved ecological conditions compared to their previous state, **particularly on degraded or heavily exploited land**. By implementing specific measures aimed at eliminating or mitigating the factors that hinder biodiversity development, these sites can become spaces that not only generate clean energy but also **actively contribute to the conservation and restoration of nature**.

Figure 23: Emissions avoided by type of primary source (MtCO2 eq)



Source: UCLM

In this estimate, the baseline scenario assumes that the substitution mainly affects combined cycle plants. Photovoltaic generation has more significantly displaced this technology, preventing **17.7 $MtCO_2$ eq** emissions in 2024, up from the **14.7 $MtCO_2$** eq estimated in 2023. Gas remains the most impacted fossil fuel due to the increasing presence of photovoltaic energy in the energy mix, since it primarily serves as a backup technology.

IN SPAIN ALONE, PHOTOVOLTAIC SOLAR ENERGY HAS AVOIDED 17.7 MTCO2 EQUIVALENT

Solar photovoltaic energy has established itself as a crucial component in the decarbonisation of the Spanish electricity system, aligning with the national trend of reducing emissions by replacing fossil fuel generation with renewable energy sources. As it operates without emitting greenhouse gases, it plays a vital role in reducing the carbon footprint and improving air quality. Furthermore, a photovoltaic panel offsets the emissions from its manufacturing within just **6 to 9 months** of use, while its lifespan is **25 to 30 years**, thereby maximising its positive environmental impact.

3.2. NEW NATIONAL REGULATION

3.2.1. Sectoral framework

IN 2024, CRUCIAL ADMINISTRATIVE MILESTONES FOR THE DEVELOPMENT OF PHOTOVOLTAIC PROJECTS WERE EXTENDED

The year 2024 was defined by numerous public consultations and challenges in passing legislation. It was also the year when **negative price hours** emerged in the electricity market, underscoring the urgent need to speed up the deployment of storage systems. Problems related to the six-month system for extending administrative milestones remain unresolved.

The effects of the DANA influenced legislative activity in 2024, leading to the introduction of **several Royal Decree-Laws** in the last quarter to mitigate its impact.

Royal Decree-Law 4/2024

In June 2024, the Council of Ministers approved Royal Decree-Law 4/2024 on 26 June, which extended measures to tackle the economic and social fallout from the conflicts in Ukraine and the Middle East, while also introducing urgent actions in taxation, energy, and social affairs.

This Decree-Law included specific energy measures, such as temporarily extending discounts on the social electricity tariff, prolonging the flexibility of electricity supply contracts, and continuing the support mechanism to ensure the competitiveness of energy-intensive industries, among others. Additionally, amendments were made to Law 24/2013 on the electricity sector related to the information that electric vehicle charging providers must supply.

Royal Decree-Law 10/2024: Temporary Energy Levy.

At the end of December 2024, the government approved Royal Decree-Law 10/2024, introducing a temporary energy levy for 2025 on major energy operators.

However, due to political uncertainty, **Parliament did not ratify this Decree-Law in January 2025**, leading to its repeal.

RD 662/2024: Regulatory Framework for Floating Photovoltaics

On 9 July, Royal Decree 662/2024 set the rules for installing **floating photovoltaic plants** on reservoirs within the public water domain, specifically in river basins managed by the General State Administration. It also amended the Public Water Domain Regulations, initially established by Royal Decree 849/1986.

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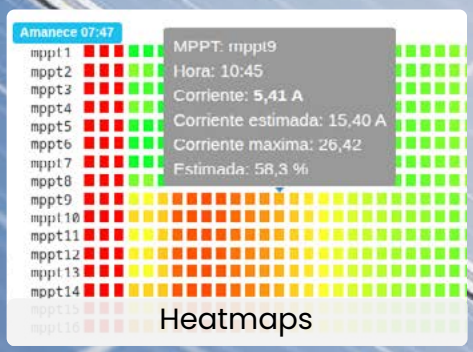

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RD 662/2024 ESTABLISHED A REGULATORY FRAMEWORK FOR FLOATING PHOTOVOLTAICS

The decree aimed to define the legal and technical conditions for a more efficient processing of applications, using a unified procedure to jointly address the prior administrative authorisation for the electricity sector and the public water domain concession, in accordance with the Water Law.

The regulation restricted concessions to **artificial or heavily modified water bodies**, allowing exceptions for protected areas only with explicit authorisation. It also set a **cap on the maximum percentage of usable surface area**, allowing 5% for non-eutrophic reservoirs and 15% for eutrophic ones. One of the significant innovations introduced by the Royal Decree is the ability to process and **grant public water domain concessions and prior administrative authorisations** simultaneously through a "one-stop shop" procedure. This approach greatly streamlines the process for developers of renewable energy projects.

Order TED/353/2024

Order TED/353/2024 set the remuneration values for the second half of 2023, applicable to renewable energy, cogeneration, and waste facilities. It also approved new standard facilities with their remuneration parameters, introducing important adjustments to the Specific Remuneration Regime (**RECORE**).

The main change involved revising the methodology for calculating the upper and lower limits (LS and LI) of the VADPM (Value Adjustment for Market Price Deviations). **Instead of using actual entry data, the revised method employs estimated technological entry data**. This change aimed to prevent calculation inaccuracies, as using actual data against estimated pool prices did not align with the **VADPM's** purpose of compensating for the difference between forecasted operational remuneration prices and the actual prices received by the facilities.

3.2.2. Regional regulations

Legislative progress on energy transition and climate change made strides across the various autonomous communities.

Andalusia

In January 2024, the Andalusian Regional Government approved Royal Decree-Law 1/2024, amending several decrees related to business aid. Improvements were made to conditions for **aid for investment in energy efficiency**, with aid intensities reaching up to 100% in some cases and the possibility of reducing them to 22.5%. Aid for building projects was extended **beyond the de minimis rules**, and in the areas of renewables, hydrogen, and cogeneration, subsidies covering total investment costs

were introduced, simplifying the calculation process. Support for the circular economy was also expanded, with a 5% increase in aid intensity, reaching up to 100% for energy infrastructure and an additional 10% for studies.

Additionally, various resolutions were introduced **to promote renewable energies, self-consumption, and storage**. These included modifying RD 477/2021 to incorporate self-consumption and storage, **extending its validity until 2024, and strengthening and expanding aid and incentives**.

Aragon

In 2024, Aragon **revamped its energy regulatory framework, introducing measures related to renewable energy taxation, increased funding, and support for energy communities and industrial self-consumption**. In May, **Law 2/2024 was passed, introducing environmental taxes** on wind and photovoltaic farms that occupy more than 5 hectares, in line with UNEF's proposals. This law excluded certain self-consumption arrangements with surpluses, included rebates for others, and established tax deductions for developers who invest in socio-economic improvement programmes and initiatives to combat depopulation, consistent with UNEF recommendations.

In December 2024, Aragon approved **Law 5/2024** on 19 December, which promoted **industrial self-consumption, energy communities, and energy planning**. It reinstated content from Decree-Law 1/2023, previously annulled by the Constitutional Court. The law took effect on 31 December 2024 and **covered various areas, including self-consumption with and without surpluses, energy communities**, direct lines, closed networks, and projects of regional interest. It also established the **Permanent Energy Forum** and mandated the creation of a new **Energy Plan for Aragon**, which will feature public participation and environmental assessment. Furthermore, the law set out priority procedures for industrial decarbonisation projects, introduced measures for electric vehicles, established an energy solidarity fund, and adapted existing regional regulations to ensure regulatory consistency.

Asturias

In 2024, an **amendment to Decree 63/2022** of 21 October, which outlines the Principality of Asturias' land use and urban planning regulations (ROTU), **was opened for public consultation**. The Department proposed this revision to manage the high number of applications for access and connection for storage, which were placing considerable pressure on rural areas. They suggested defining a land use planning model to address this issue. During the amendment process, **urban planning applications for non-developable land were suspended, and proposed minimum distances were set at 1 km from urban centres and 500 m from livestock or forestry facilities**. UNEF criticised these measures as

a ‘de facto ban,’ citing a lack of technical or scientific justification. The amendment to Decree 63/2022 was ultimately approved in 2025 through Decree 89/2025 on 30 June.

Aid for renewable self-consumption facilities and thermal systems continued under the state programme RD 477/2021 (Recovery Plan), with applications processed and deployment ongoing in 2024.

Balearic and Canary Islands

In September 2024, **Order TED 1035/2024 was issued concerning the SOLBAL I and II and SOLCAN I aid programmes**, which introduced significant changes to expedite aid payments. The most notable change allowed for funds to be paid once photovoltaic installations were completed and provisional certification was issued, without waiting for final certification, thereby reducing administrative delays.

In the **Balearic Islands**, the government approved Decree-Law 3/2024 on 24 May, which took effect on 29 May and was ratified by Parliament on 20 June. This decree included **measures to streamline administrative procedures in environmental and energy sectors**. However, **it was repealed on 14 December by Law 7/2024**, which partially upheld its measures and accelerated authorisations while reducing bureaucracy in energy, urban planning, and transport. Additionally, subsidies for photovoltaic and thermal self-consumption were extended under the NextGenerationEU Plan.

In the **Canary Islands**, **Royal Decree-Law 5/2024**, published on 24 June, amended Law 6/2022 on Climate Change and other regulations. It simplified **authorisations for transport networks, streamlined guarantees for distributors, and established local participation requirements** in renewable projects, mandating 20% local involvement for projects of 2 MW. The concept of renewable acceleration zones was introduced, and a two-year timeframe was set for regulating agrovoltaic installations. Moreover, on 26 August 2024, an **order was published setting the rules and announcing subsidies for energy communities**, under Programme 2, Line 2 of the Sustainable Energy Strategy in the Canary Islands, funded by Next Generation EU.

Cantabria

In Cantabria, 2024 saw little in the way of regulatory activity, with the exception of a public consultation on updating the **Environmental Control Law**. In April 2025, the regional government approved a bill to replace the 2006 law. The proposed measures include **establishing an inspection unit empowered to impose fines** of up to €500,000, **clarifying procedures** (such as the use of affidavits versus environmental authori-

sations), and **transferring environmental control responsibilities** to the Directorate-General for the Environment.

Castile-La Mancha

The Directorate-General for Coordination opened the **Draft Law on Administrative Simplification and Streamlining** to public consultation, during which UNEF requested an amendment to Article 55 of the LOTAU. This amendment aimed to clarify how the general rule applies to projects requiring environmental impact assessment, prohibiting activities on rural land that obstruct views, disrupt the landscape, or spoil the scenery of urban areas, roads, and paths.

The Regional Ministry of Sustainable Development incorporated the amendments from **RD 445/2023** into regional legislation through the Environmental Assessment Law. This expanded the range of projects requiring either ordinary or simplified assessments, removed certain thresholds, and introduced new criteria for determining when a project should move from a simplified to an ordinary assessment. Finally, **Order 72/2024**, dated 9 May, approved the revision of the **Management Plan for SPAs dedicated to steppe birds**, aligning it with European regulations on wild birds and protected areas.

Castile and León

Decree 3/2024, dated 29 February, reformed the Regulations of the **Regional Public Energy Agency** (Decree 30/1997), modernising its organisational structure and functions to align with new energy requirements. **Law 4/2024**, issued on 9 May, concerning tax, financial, and administrative measures, **introduced changes to environmental regulations**. It amended the Environmental Prevention Law (Legislative Decree 1/2015) and made adjustments to the Natural Heritage Act (Act 4/2015) to enhance the protection of rural land within the Natura Network and improve the regulation of Master Plans.

In September 2024, **Order EYH/911/2024** established and regulated the **Register of Electricity Self-Consumption** and the **Register of Electricity Production Facilities in Castile and León**. This initiative aimed to facilitate the registration, control, and transparency of self-consumption in the region.

Catalonia

In 2024, a draft **Decree-Law on energy storage** was developed, which is still awaiting final approval. This draft **included battery installations as public or social utility infrastructure**, making it easier to implement them on non-developable land.

The **Decree-Law 16/2019 on renewable energies was also updated to explicitly recognise energy storage**, clarify authorisation procedures, and streamline administrative processes.

At the time of reviewing this section, the Decree on storage had not been ratified by the Parliament of Catalonia and was subsequently repealed.

Community of Madrid

In 2024, the Community of Madrid enacted **Law 7/2024**, dated 26 December, concerning Measures for Balanced Development in Environmental and Land Use Planning. This omnibus law revised the Land Law (Law 9/2001) and the Land Use Law (Law 9/1995). It **permits energy and telecommunications infrastructure to be established on undeveloped or protected non-developable land** without urban planning permits, requiring only sectoral permits and a municipal report (with positive silence within one month). The law also broadened the conditions for a responsible declaration for photovoltaic self-consumption and charging points, except in protected areas, and extended the statute of limitations for urban planning violations to six years for general land and fifteen years for protected non-developable land.

Territorial planning instruments were restructured to clarify the hierarchy of plans, promote rural revitalisation, and simplify urban planning. Additionally, a **Special Infrastructure Plan** was introduced to legitimise photovoltaic projects, **incorporating the joint application process for Preliminary Administrative Authorisation (AAP) and Construction Administrative Authorisation (AAC)**, ensuring the dismantling of facilities. Furthermore, a draft decree by the Governing Council was submitted for public consultation. This decree covers procedures for authorisation, communication, verification, inspection, responsibilities, and penalties for high-voltage electrical energy facilities in the Community of Madrid.

Valencian Community

The year 2024 in Valencia was defined by the devastating impact of the DANA, a high-altitude isolated depression. On 9 July, Royal Decree 7/2024 on **administrative simplification by the Valencian Regional Government** was approved. The regulation consolidates all regulations related to renewable energy installations into a single sectoral framework, reducing regulatory fragmentation. It clarifies previously confusing **definitions**, such as those for **PV plants** and stand-alone **energy storage facilities**. The maximum occupancy limit for photovoltaic plants has been increased to 10% of non-developable land (both common and protected, collectively) in each municipality. To ensure legal certainty in urban planning procedures, **local councils are prohibited from suspending licences** that affect the processing of renewable energy generation projects. The content of urban planning compatibility reports is now regulated to focus strictly on urban planning and territorial issues.

Law 6/2024, dated 5 December, on *Measures for Administrative Simplification and Regulatory Improvement*, was approved. It includes significant amendments in the fields of environmental quality, climate change, protected areas, animal welfare, and livestock trails, as well as

in land use and energy. It also impacts the Climate Change Act (6/2022) and the Act on Prevention, Quality, and Environmental Control of Activities (6/2014).

Extremadura

Throughout 2024, Extremadura did not pass any decree-laws related to energy, climate, or urban planning. However, in **April 2024**, a **methodological proposal was published to determine acceleration zones** for renewable energy projects, based on the region's **capacity maps**.

Galicia

In Galicia, **Law 2/2024 was enacted** in November 2024 **to enhance the social and economic benefits of projects utilising the region's natural resources**. The primary aim of the law is to ensure responsible management of these resources, balancing environmental protection, wealth creation, and the positive impact of this wealth on the region.

The law **requires social impact studies and assessments of ecosystem services for planning and executing projects** that use natural resources. It also aims to ensure these projects provide a tangible return to the social and economic environment, prioritising collective well-being and sustainability.

La Rioja

In **January 2024**, the Parliament of La Rioja passed **Law 1/2024**, introducing urgent temporary measures to protect the region's landscape. This law stipulated that once the targets of the **Riojan Integrated Energy and Climate Plan (PRIEC)** are met, the declaration of public utility for new renewable energy facilities would no longer be backed by the Electricity Sector Law. It also strengthened the application of the **European Landscape Convention** by legally recognising landscapes as key elements in land use and urban planning policies (Law 5/2006). The law put an immediate **halt** to the procedures for recognising public utility and granting authorisations for electricity generation projects and their associated infrastructure on non-developable land. Exceptions apply to self-consumption facilities without surplus and projects that have already completed the public information phase.

Additionally, on **4 October 2024**, the **Draft Law on Fiscal and Administrative Measures for La Rioja for 2025** was published, introducing an **environmental and visual tax** on **wind and solar power installations**. This extra-fiscal, compensatory tax applies to both operational and unused facilities until they are entirely dismantled. The **tax base** is determined by the size of the infrastructure, the number of wind turbines, and the enclosed area of solar plants. A **rate of €350/ha** was set for photovoltaic parks, with exemptions for self-consumption facilities and those with a capacity below 5 MW, unless they are connected to a common evacuation line with a total capacity above that threshold.

Murcia

The **Strategic Subsidy Plan** of the Regional Ministry of the Environment, Universities, Research and the Mar Menor for the 2024 financial year was approved by **Order on 9 February 2024**. This plan was subsequently amended on several dates — **23 April, 26 April, 30 April, 3 June, 13 June, and 28 June 2024** — to **update and introduce new subsidy lines** within the **442J Clean Energy programme**.

Navarre

In 2024, Navarre continued implementing **Regional Law 4/2022**, promoting self-consumption, efficiency, and distributed generation, while advancing the establishment of the **Navarre Energy Transition Agency (ATENA)**. In April 2025, **Regional Law 4/2025** was approved, defining ATENA's functions: executing the Energy Plan, managing public investments, and supporting energy communities, efficiency, and renewable R&D.

That same year, the regional government launched a funding **call for industrial decarbonisation for 2025–2026**, with €2.5 million allocated for 2025 and €1 million for 2026, plus an additional €700,000. The support was targeted at SMEs and large emitting companies, covering efficiency, photovoltaic self-consumption, and energy storage. Subsidies could cover up to **50%** of eligible expenses, with maximum limits of **€300,000 for efficiency and €200,000 for self-consumption**, focusing on energy and territorial impact.

Basque Country

On 8 February 2024, the Basque Parliament passed **Law 1/2024 on Energy Transition and Climate Change**. This law, which builds on a 2021 draft, establishes a regulatory framework for the Basque Country. It introduces governance mechanisms, promotes citizen participation and **imposes a levy on renewable energy installations to offset environmental impacts**.

The "Renewable Energy Levy" is a direct and recurring charge aimed at mitigating the environmental effects of renewable energy installations on non-developable land. The levy applies to both existing and new installations and the revenue generated will be allocated to fund the conservation and restoration of the affected environments. Owners of these installations are responsible for the **levy, which is set at €700 per hectare impacted**, adjusted proportionally for the first and last year of operation. The law provides exemptions for self-consumption facilities and those generating less than 5 MW.

3.2.3. Access and connection

CNMC Circular 1/2024 on Demand

On 27 September 2024, the National Commission for Markets and Competition (CNMC) issued Circular 1/2024 on demand. This document sets out the **methodology and conditions for accessing and connecting to the transmission and distribution networks for electricity demand facilities**. This Circular, highly anticipated across the sector, addresses many of the industry's requests regarding permits for access and connection related to demand. It streamlines the process for applying for and granting permits for consumer access and connection to transmission and distribution networks. Additionally, it establishes a regulatory framework for developing flexible access permits and mandates electricity distribution companies to create platforms to manage and track access and connection permit applications. Furthermore, this Circular revises Circular 1/2021 on generation, shifting the acceptability criterion to focus on access capacity rather than installed power.

The main innovation in this Circular is the **introduction of various types of access permits**, enabling new flexible demand that does not require firm security of supply to connect to the grid. This applies to manageable consumption patterns that can be concentrated at specific times of the day. The specific conditions for determining firm and flexible capacity will be outlined in several annexes, detailing the **Detailed Specifications**, both firm and flexible, for transmission and distribution networks. **These Detailed Specifications will be approved in 2025**. For the Detailed Specifications for Firm Demand, the approved text is expected to be final. However, for Flexible Demand, the text may incorporate various types of flexible access permits over time. These flexible access permits for transmission and distribution networks aim to optimise their use by allowing more energy to flow per unit of granted access capacity or contracted power.

THE DEMAND CIRCULAR STANDARDISES CONDITIONS FOR ACCESS AND CONNECTION TO TRANSMISSION AND DISTRIBUTION NETWORKS FOR DEMAND FACILITIES.

The proposal **emphasises transparency by** suggesting a web platform to process demand requests, which will differentiate requests from downstream distributors and streamline the management of network access applications for self-consumption and electric vehicle charging infrastructure. Additionally, the transparency measures include publishing the granting of permits for demand facilities and requiring grid operators to disclose information about network node access capacity.

Just Transition Tenders

Order TED/345/2024, dated 9 April, set out the procedure and requirements for granting evacuation access capacity to the electricity transmission grid at Just Transition nodes (Garoña 220 kV, Guardo 220 kV, Lada

400 kV, Mudéjar 400 kV, and Robla 400 kV). This applies to synchronous generation modules from renewable sources and synchronous storage.

This order is part of the **Just Transition Strategy**, within the framework of the National Integrated Energy and Climate Plan (PNIEC) and the Recovery Plan. Its goal is to replace the capacity of decommissioned thermal and nuclear power plants with renewable generation that enhances the stability of the electricity system, while also boosting economic activity and employment in the affected areas.

Table 8: Access capacity per node

Just transition node name and voltage	Access capacity for synchronous generation modules (MGES)
Garoña 220kV:	151
Guardo 220kV:	216
Lada 400kV:	90
Mudéjar 400kV:	154*
Robla 400kV:	648

Source: Order TED/345/2024

The regulation set the **maximum available capacity** for synchronous generation at each node and defined a concession procedure based on the **principle of temporal priority**, with additional requirements for applicants. They had to demonstrate legal and technical capacity, provide financial guarantees, and commit to socio-economic initiatives. These included **promoting self-consumption** (2 kW for each MW requested), **offering training** (1 beneficiary per MW with at least 100 hours of instruction), and **creating jobs** (1 full-time equivalent job per MW). Additionally, up to 20% of the project area could be located in neighbouring municipalities, provided they fall within the scope of the **Just Transition Agreements**.

The order introduced a definitive guarantee of €120/kW to ensure compliance with socio-economic commitments. This guarantee would be verified and released through external audits within a maximum of six years (or ten years for reversible pumping projects). If commitments are not met, the guarantees will be enforced and access rights forfeited. Additionally, the order regulated the additional capacity available, including the capacity reserved for small installations at the Mudéjar node. It also ensured transparency in the process by requiring the publication of information and monitoring the commitments made by developers.

TED/345/2024 ESTABLISHED ACCESS AT FAIR TRANSITION NODES AND PRIORITISED SOCIO-ECONOMIC IMPACT.

- Narcea Node Tender: 400 kV

  On 26 December 2024, **Order TED/1471/2024** was published, setting the regulations for the tender granting access capacity at the Narcea Just Transition node (400 kV). Some UNEF proposals were included, such as ensuring non-discrimination

against neighbouring municipalities and removing the size limit for the application ZIP file. The tender outlined an indicative access capacity of 744 MW for storage, with a maximum of 154 MW at Narcea 132 kV and 27 MW at Vega de Rengos 50 kV. The selection criteria were based on technical, socio-economic, maturity, and environmental impact factors, with a maximum score of 100 points. Applicants were required to meet technical and legal standards and commit to employment, self-consumption, local investment, and sustainability initiatives. They also needed to provide guarantees of €120/kW.

- Meirama Node Tender: 220 kV

  Order TED/1469/2024, published on 26 December 2024, laid out the rules for the tender for access at the Meirama Just Transition node (220 kV). As with other tenders, UNEF's suggestions, such as the inclusion of neighbouring municipalities and the simplification of documentation, were incorporated. The tender considered a guideline capacity of 399 MW for storage and allowed connections to underlying distribution networks. Evaluation criteria were categorised into technology, socio-economic impact, maturity, and environmental impact. Facilities were to be primarily located in the Valle del Caudal Just Transition Zone, with up to 20% permitted in adjacent municipalities in A Coruña. Socio-economic commitments involved local employment, training, self-consumption, and investments in the province's value chain.

- La Pereda Node Tender: 220 kV

  Order TED/1470/2024, also published on 26 December 2024, set the regulations for the tender to access the La Pereda Just Transition node (220 kV). The System Operator indicated an indicative capacity of 214 MW for storage. The evaluation of applications used the same scoring criteria as other nodes: technology (up to 20 points), socio-economic impact (64 points), maturity (6 points), and environmental impact (10 points). Facilities needed to be located within municipalities in the Valle del Caudal Just Transition Zone, with up to 20% of the area allowed in neighbouring municipalities. Commitments were required in areas such as employment, training, self-consumption development, circular economy, and biodiversity, supported by a financial guarantee of €120/kW.

Detailed specifications

In July 2024, the CNMC approved the **detailed specifications for generation access capacity to electricity networks (Resolution RDC/DE/002/24)**. The resolution introduced new detailed guidelines for calculating grid access capacity for electricity generation facilities, expanding upon Circular 1/2021. It applies uniform criteria across grid operators, thereby facilitating the integration of new renewable generation, storage, and demand facilities.

For the **transmission network**, the resolution specifically addressed the dual nature of storage, acknowledged Grid Forming technology, and outlined the use of Synchronous Compensators (SC). In the **distribution network**, it incorporated the concept of the Contribution Factor (CF) to evaluate flows under N-1 conditions and included references to storage and synchronous compensators. Network operators have been given a transitional period until 2 December 2024 to adapt their calculations and update the information on available capacity.

Order TED/1487/2024, dated 26 December, on system charges and the subsidised rate

The financing of the **subsidised rate** was governed by Royal Decree-Law 10/2022 and Royal Decree 897/2017, with costs distributed among the electricity system agents: producers, transmission operators, distributors, retail suppliers, and direct market consumers. The **CNMC** calculated the financing percentage and unit values for each segment based on their turnover, energy production, or number of customers (€/MWh or €/CUPS, where CUPS stands for Universal Supply Point Code). **In 2025, the unit value for production was set at €0.432343/MWh**, while the retail supply value reached **€4.650987/CUPS**. The overall cost distribution was allocated as follows: 40.63% for producers, 1.74% for transmission, 8.36% for distribution, 48.45% for retail supply, and 0.82% for direct consumers.

THE TENDERS IN NARCEA, MEIRAMA, AND LA PEREDA TOTALLED 1,350 MW, ASSESSING EMPLOYMENT AND SUSTAINABILITY.

Order TED/1487/2024, dated 26 December, revised the charges for the electricity system and authorised the allocation of funding for the social tariff and supply to vulnerable consumers for the 2025 financial year. The order included adjustments funded by the system surplus (€420 million from the 2023 surplus) and established the final unit values for each activity, along with the energy and power terms for every tariff segment, including electric vehicle charging points. It also governed capacity payments, compensation for the additional cost of non-mainland systems (€836 million), and the distribution of the historical deficit (€2.39 billion related to FADE and the 2013 deficit).

A forecasted **20.17%** drop in turnover reduced producers' contributions by **6.4%**. The adjustment to the social tariff compared to 2024 was partly due to corrections from previous years. Despite the decline noted in 2024, the subsidised rate for 2025 remained lower than in 2023, indicating a trend towards stabilisation after correcting past excesses in cost calculation and distribution.

Operating Procedure 7.4 - Voltage control

In June 2025, the CNMC approved Operating Procedure 7.4, which governs the **complementary voltage control service in the transmission grid, a** crucial element for ensuring the quality and security of the electricity supply. This service is provided through **reactive power management**, involving both the generation and absorption of reactive power by generators, transmission companies, distributors, and large consumers (≥15 MW). The System Operator (REE) manages the process

by setting voltage setpoints and monitoring real-time compliance via telemetry.

Generators with a capacity of ≥30 MW, as well as smaller generators whose combined capacity reaches this threshold at a single node, **must maintain a minimum reactive power margin (±15% of their maximum active power)** . They can also offer additional resources, such as acting as synchronous compensators. Consumers and distributors need to adhere to strict power factor limits based on time periods to prevent either the delivery or excessive consumption of reactive power.

The procedure also outlines the annual and daily processes for programming and resource allocation, measurement and control methods (with sampling every 5 to 10 minutes), and the regulated remuneration for additional reactive resources used, including penalties for non-compliance. This framework enables investors and renewable energy systems to participate in voltage control by providing grid support services.

3.3. PHOTOVOLTAIC SELF-CONSUMPTION AND ENERGY COMMUNITIES

Photovoltaic self-consumption continued to be a profitable and sustainable option, providing users with greater energy independence. Increasingly, installations incorporated storage solutions, enabling energy use during peak times and reducing grid congestion.

Energy communities (ECs) serve as the most comprehensive tool within the distributed energy ecosystem. They encompass all key aspects of the ecological transition: renewable electricity generation and consumption, energy efficiency, sustainable mobility, storage, and demand aggregation. Moreover, they encourage the active involvement of citizens, society, and the economy—especially at the local level—alongside local authorities.

IN 2024, 1,182 MW OF SELF-CONSUMPTION WAS INSTALLED IN SPAIN, MARKING A 31% YEAR-ON-YEAR DECLINE.

3.3.1. Regulatory developments

Draft Royal Decree on electricity self-consumption

At the end of 2024, the Ministry for Ecological Transition and the Demographic Challenge initiated a public consultation on the draft **Royal Decree concerning electricity self-consumption**. This move aimed to update the administrative, technical, and economic conditions nearly six years after the existing regulation, **Royal Decree 244/2019**, came into force. The review aimed to simplify procedures, optimise the management of surpluses, integrate storage solutions, promote shared

self-consumption, and support the development of energy communities. It adapted the regulatory framework to accommodate technological advancements and the evolving landscape of the electricity system.

Royal Decree 244/2019 had established the groundwork for self-consumption in Spain, defining non-isolated models for the first time—those without surpluses, those with surpluses eligible for simplified compensation, and those with surpluses not eligible for compensation—, as well as providing a framework for collective self-consumption. However, the sector's requirements had changed, necessitating proposed regulatory amendments. These included extending the exemption from access and connection permits to all installations supplying less than 15 kW, increasing the threshold for simplified processing to 500 kW, permitting the distribution of surpluses as well as generation, removing the requirement to install generation meters in collective self-consumption setups, and developing the role of the collective self-consumption manager. The first draft of this new Royal Decree was anticipated to be published in 2025.

Self-consumption Dialogue Meetings - CNMC

Throughout 2024, the CNMC (National Commission for Markets and Competition) organised **Self-Consumption Dialogue Meetings**, bringing together key stakeholders in the sector. The main **aims of these meetings were to analyse self-consumption challenges, identify barriers, and discuss potential regulatory measures to promote self-consumption**.

Non-Legislative Proposal Submitted to Parliamentary Groups

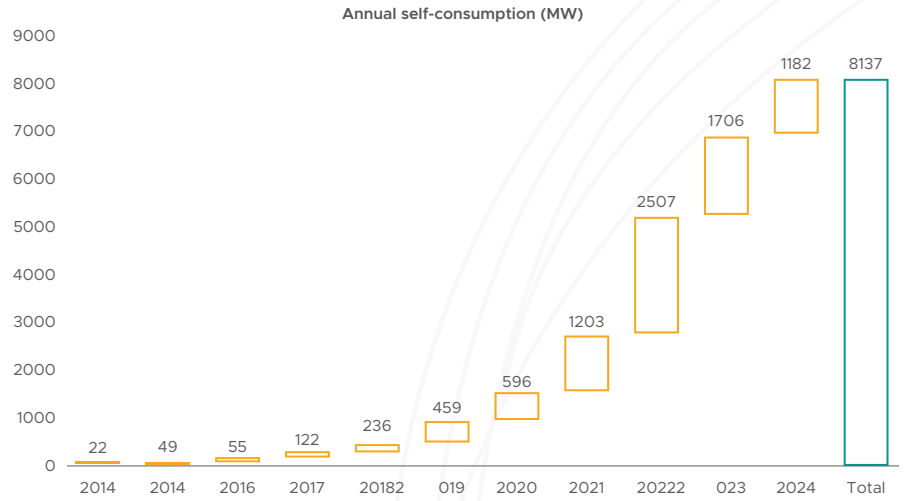
In early March 2025, **UNEF, along with the Alliance for Self-Consumption**, submitted a non-legislative proposal (PNL) to the parliamentary groups in the Congress of Deputies. This proposal aimed to strengthen the suggestions from the earlier public consultation and incorporate new measures not previously considered.

The PNL, which has been registered but not yet presented in a plenary session, contains twelve proposals focused on modernising the self-consumption regulations. These include introducing the role of a **self-consumption manager**, allowing the **sharing of surpluses** with a portion allocated to vulnerable consumers, and enabling **monthly modifications** of collective contracts. It also suggested simplifying access and connection with implicit approval, increasing the **thresholds for simplified compensation** to 450 kW, and extending **permit exemptions** for installations under 15 kW. Furthermore, the proposal called for a **standardised procedure** nationwide, increased transparency in transformation centres, and a greater **allowable distance** between generation and consumption points with reduced tolls. Additionally, it advocated for the introduction of **dynamic distribution coefficients**, regulation of **distributed storage** independent of generation, and the replacement of aid models with **tax deductions**, including income tax allowances, corporation tax reductions, and VAT cuts.

3.3.2. Self-consumption trends

The rate of self-consumption installations in 2024 **fell by 31% compared to 2023**, adding 1,182 MW of power by the end of 2024, which is 524 MW less than the previous year.

Figure 24: Estimated installed capacity of photovoltaic self-consumption

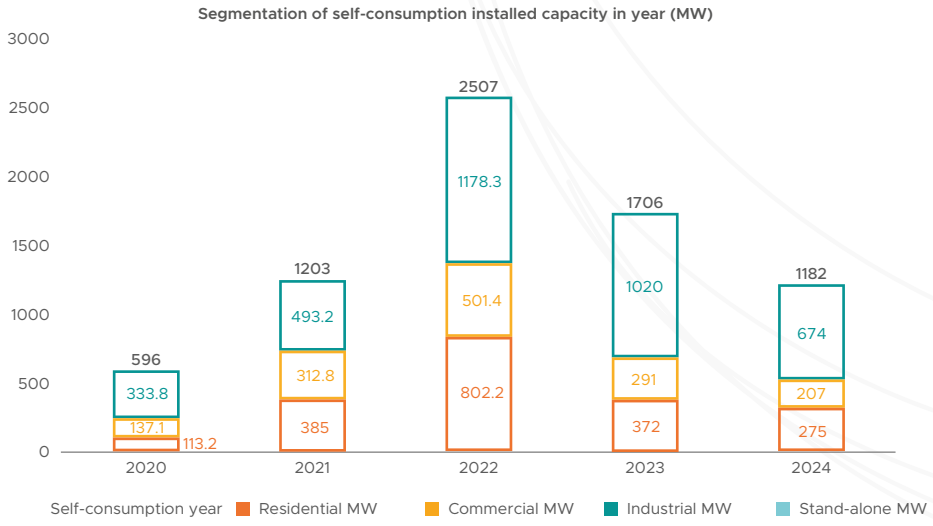


Source: UNEF

As of 2024, Spain had a cumulative total of **8,137 MW of self-consumption capacity**, still **far from the 19 GW target** set by the National Integrated Energy and Climate Plan (PNIEC) for 2030. The residential sector was the least affected by the decline, experiencing a **26%** decrease from the previous year, followed by the commercial sector at **29%** and the industrial sector at **34%**. In the industrial segment, where projects typically require longer development times, the decline might manifest with some delay compared to reductions already observed in the residential and commercial sectors in 2023.

SPAIN ACCUMULATES 8,137 MW OF SELF-CONSUMPTION CAPACITY

Figure 25: Segmentation of self-consumption installed capacity in 2025



Source: UNEF

THE RESIDENTIAL SECTOR WAS THE LEAST AFFECTED, WITH A 26% DECREASE COMPARED TO 2023

Meanwhile, off-grid installations grew by 15%, but these accounted for only 2% of the total installations in 2024.

3.3.3. Energy Communities

Regulatory Framework

Following the publication of **Royal Decree-Law 5/2023**, which included **energy communities as entities under the Electricity Sector Law**, no new state-level regulations were introduced for these entities in 2024. As a result, energy communities still lack a comprehensive regulatory framework that allows them to operate within the system on equal terms. In 2023, a draft Royal Decree intended to develop their regulation was proposed but never materialised.

According to **ECODES**, in its *Common Energy* report, there were **659 energy community projects**[1] by the end of 2024. These projects were established without a fully supportive regulatory framework.

Incentive Programme for Unique Energy Community Pilot Projects (EC IMPLEMENTA Programme)

The EC Implementa Programme, driven by the IDAE, provides **incentives for distinctive pilot projects within energy communities**. Its initial regulatory framework was established by **Order TED/1446/2021, dated 22 December**, which led to four grant calls. On 22 July 2024, **new regulations were introduced via Order TED/764/2024**, governing the allocation of this aid under the Recovery, Transformation and Resilience Plan (PRTR). This order **increased the initial budget for energy communities in the four prior rounds** of the EC Implementa Programme. The grants, financed and managed centrally by the IDAE, covered all aspects from application receipt to examination, selection, management, resolution, verification, control, and publication of each call for applications.

These grants, awarded through competitive bidding as non-repayable funds, are **available until 30 September 2026**. They are targeted at public or private legal entities that have formed an energy community to execute a specific project. The rules specify that an energy community must consist of at least **five partners or members**. Additionally, the Order includes definitions of energy communities and issues like autonomy and effective control, which, as indicated, should be included in the national regulatory framework.

THE ORDER PRIORITISED PROJECTS THAT MINIMISED COSTS, HAD MULTIPLE COMPONENTS, OR DELIVERED SOCIAL AND VALUE CHAIN BENEFITS.

1 https://www.energiacomun.org/indicadores/

Funding is available for actions of distinctive pilot projects in the following areas:

- Renewable electrical energy, which includes photovoltaic technology.
  To qualify for funding, renewable electrical energy systems must include a behind-the-meter storage system capable of storing at least 0.5 hours of the system's electrical power.
- Thermal renewable energies
- Energy efficiency
- Sustainable mobility
- Demand-side management

Table 9: Evaluation criteria. EC-Implementa Call

Assessment criterion	Maximum score	Accreditation
A. Project characteristics: 15 points		
A.1 Multi-component projects	5	Meets definition Article 2. Regulations in the project memorandum
A2 Administrative feasibility	10	Description in Project Memorandum
B. Economic viability: 70 points		
B.1 Reduction on maximum aid	70	Description in Project Memorandum.
C. Externalities: 15puntos		
C.1 Social, European value chain and gender impact	10	Description in Project Memorandum
C.5 Alignment with regional and/or local priorities.	5	Description in Project Memorandum
Total:	100	

Source: IDAE

After the new regulations were published, the **fifth call for grants was announced, offering €30 million for projects under €1 million**, and the **sixth call, providing €90 million for larger projects**. Both had an application period from 19 September to 31 October 2024.

Initially, the **deadline for processing and notifying applicants was set for 19 March 2025**. However, due to the high number of applications, the Secretary of State for Energy **extended this deadline by six months to September 2025.** In addition to these national calls, there were also supplementary grants available at regional and municipal levels.

UNEF proposals

UNEF has prepared a document with regulatory proposals at the national level, summarised as follows:

- It is essential to specify the organisational characteristics and structures that Renewable Energy Communities (RECs) should have, aligning with their definition. Therefore, **UNEF suggests that the definitions of autonomy and effective control for these communities be incorporated into the general regula-**

tory framework as they are crucial for ensuring the independence of these projects in decision-making and other matters.

- We at UNEF believe that **proximity criteria, ensuring the local nature of these projects**, should be included in the definition of Renewable Energy Communities.

- We propose **developing a supportive framework to streamline the processing** of installations associated with energy communities. This would involve assistance from relevant energy authorities within the autonomous communities and improved coordination with distribution network operators to expedite access and connection.

- UNEF emphasises the crucial role of local authorities, whose involvement strengthens projects. The **regulatory framework should therefore equip local councils with the necessary legal, fiscal, and property tools to support the development, management, and facilitation of spaces for energy communities**. UNEF proposes amending the Local Government Act to explicitly define the role of local authorities as promoters, facilitators, or managers of energy communities. We also suggest revising the Local Authority Property Regulations to allow councils to allocate municipal property for these projects.

- **We recommend establishing a register of energy communities** to ensure that registered projects meet the relevant definitions and comply with evolving state regulations, positioning them to operate within the electricity sector effectively.

- Finally, we advise promoting economic incentives, such as tax deductions for energy community members, auctions for related projects, and **ensuring their participation in Energy Saving Certificates (CAEs)**.

While there is not yet a specific state regulatory framework in place, some autonomous communities have already begun developing their own regulations. In 2024, **Aragon enacted Law 5/2024 on 19 December to promote energy communities and industrial self-consumption**, including specific provisions for these projects. However, the Constitutional Court accepted an appeal from the Government, arguing that some of its articles might be unconstitutional.

3.3.4. Aid for Self-consumption

In 2025, the **first call for expressions of interest in renewable energy initiatives within the General State Administration (RENOAGE)** was approved. This initiative aims to promote the energy transition in the GSA and its associated or dependent public bodies through co-financing **with ERDF funds**. New electricity and

thermal generation facilities from renewable sources, sponsored by these bodies, were deemed eligible for subsidies, as long as they met the criteria outlined in the call. A budget of **€312.3** million was allocated**, with the option to increase** it if funds were depleted before the application period closed. Applications opened on 1 April 2025 and will remain open until 30 March 2026.

Additionally, **deductions for energy efficiency improvements**, governed by **Royal Decree-Law 8/2023, continued**. Only the deduction for energy renovation works remains in effect. To support its implementation, the IDAE, in collaboration with the General Council of Economists and the Spanish Council of Architects, prepared the IDAE Tax Relief Guide. Several autonomous communities continued to offer subsidies for self-consumption, energy communities, and energy efficiency. In many instances, these included **grants for installations with energy storage**.

3.4. HISTORICAL DATA

This section has been prepared using data compiled and published in successive annual reports available up to now. The historical data presented may vary due to updates from the system operator, changes and consolidation in industry data, the number of companies surveyed, or differences in the databases used and their categorisation criteria.

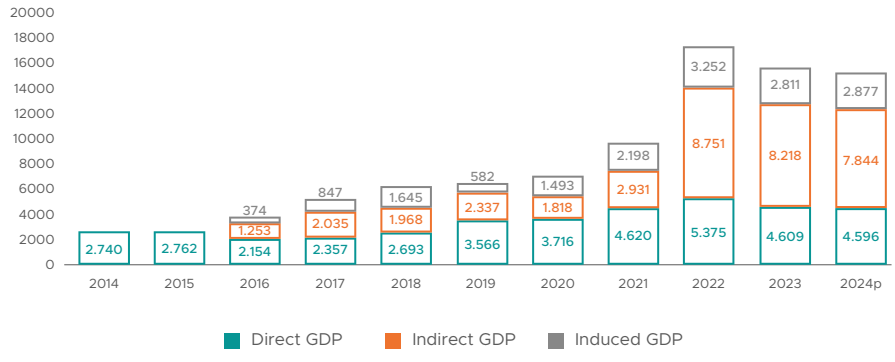
3.4.1. Economic impact of the photovoltaic industry

Over the last decade, the photovoltaic sector in Spain has transformed from off-grid installations, typically used in agriculture, to becoming the **leading technology in terms of installed capacity**. This structural transformation has increased its economic significance as well.

In **2014**, the industry's total impact on the national GDP was approximately **€2.74 billion**. Since then, the sector has experienced continuous growth, particularly from 2018 onwards, when its total contribution rose to **€6.307 billion**. This growth trajectory was driven by the deployment of new capacity and the strengthening of the national value chain.

By **2024**, the sector's total impact reached **€15.317 billion**, over **five times** the figure for 2014 and just below the 2022 record high of **€17.378 billion**. This outcome signifies the sector's sustained high activity levels following significant recent expansion. The direct impact was **€4.596 billion**, the indirect impact **€7.844 billion**, and the induced impact **€2.877 billion,** demonstrating that the sector's growth has brought a notable multiplier effect on the national economy.

Figure 26. Historical data. Contribution of the Spanish photovoltaic sector between 2014 and 2024 to national and foreign GDP (millions of euros)



Source: UCLM and UNEF

As the data indicates, while 2022 saw a historic peak in economic contribution, **the sector remained robust in 2023 and 2024**, thanks to steady installation of ground-mounted plants. However, a 30% average annual decrease in self-consumption signals a shift in the expansion rate of this segment, influenced by a slowdown in residential demand and adjustments to incentives.

IN 2024, THE PHOTOVOLTAIC SECTOR'S TOTAL IMPACT ON GDP WAS €15.317 BILLION, OVER FIVE TIMES THE FIGURE RECORDED IN 2014.

Since the abolition of the sun tax (known as in Spanish, which was a charge on solar energy producers) in 2018, a charge previously imposed on solar energy producers in Spain, the photovoltaic sector has cumulatively contributed over **€77.9 billion** to GDP and generated more than **€11.6 billion** in tax revenue, including national and local taxes and social security contributions. These figures demonstrate that, despite some adjustments in certain segments, photovoltaics continues to be a major economic driver for Spain and a reliable source of public revenue.

Table 10: Fiscal balance (millions of euros)

	2018	2019	2020	2021	2022	2023	2024p
TAX REVENUE							
National taxes	602.0	764	954	1320.6	1656.8	1586.3	1536.2
Local taxes	22.9	130	110	153.6	242.4	238.8	270.4
National insurance contributions	186.0	233	237	347.5	389.5	336.6	344.6
Total tax revenue	810.9	1126.4	1301.2	1821.7	2288.8	2161.7	2151.2
TAX BENEFITS							
Investment grants	18.7	19	67	81.6	164.5	230.8	177.7
Tax rebates (ICIO and IBI)	1.6	5	6	12.0	24.9	17.0	11.8
Total tax benefits	20.3	24	73	93.6	189.5	247.8	189.4
TAX BALANCE	790.6	1102.7	1228.0	1728.1	2099.3	1913.9	1961.8

Source: UCLM and UNEF

At the local level, the sector generated €270.4 million in revenue in 2024, marking a 13.1% increase from 2023 and an 11.6% rise compared to 2022. This influx of funds **bolsters the financial capacity of thousands of municipalities**. If local authorities manage these resources effectively, they can drive more sustainable regional development, address depopulation, and generate wealth in rural Spain by improving infrastructure and enhancing public services.

SINCE 2018, THE SECTOR HAS ADDED MORE THAN €77.9 BILLION TO GDP AND GENERATED OVER €11.6 BILLION IN TAX REVENUE FOR PUBLIC FINANCES.

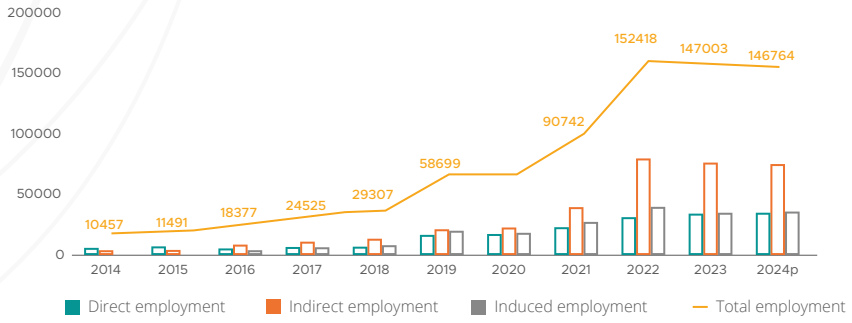
Since 2018, **the sector has contributed over €1.168 billion in local taxes**, providing a steady flow of income that strengthens the economies of numerous municipalities, particularly in rural areas. This revenue boost has facilitated local economic growth, helped stabilise populations, and stimulated complementary activities, establishing photovoltaics as a **catalyst for regional revitalisation and social cohesion**.

IN 2024, THE SECTOR CONTRIBUTED €270.4 MILLION IN LOCAL REVENUE, FOSTERING DEVELOPMENT AND COHESION IN RURAL SPAIN

3.4.2. Impact of the photovoltaic industry on employment

Considering the entire value chain, total employment in the photovoltaic sector reached **146,764 jobs** in **2024**, maintaining the high levels achieved in 2022 and 2023 following significant growth in previous years. **Direct** employment held steady at about **35,105 people**, while **indirect employment** rose to **75,569**, making it the largest employment segment. **Induced employment** was **36,090**, highlighting the ripple effect of photovoltaic activities on other economic sectors.

Figure 27. Historical series: Job creation trends by employment type from 2014 to 2024.



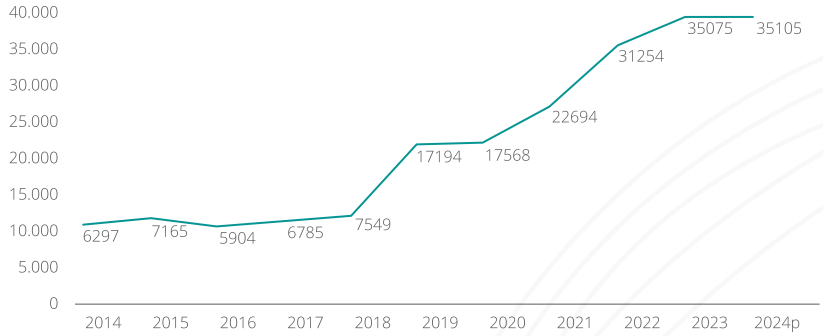
Source: UCLM and UNEF

Over the past decade, job growth in the Spanish photovoltaic sector has been strong and consistent, marked by key events that have significantly boosted job creation. The **removal of the sun tax in 2018**, for instance, immediately energised the sector, while the **introduction of auctions and new administrative milestones in 2020** reinforced confidence and long-term planning. **Although 2022 saw a historic high** in total employment, the figures have remained **high and stable**, indicating the sector's consolidation.

SINCE 2018, EMPLOYMENT IN THE PHOTOVOLTAIC SECTOR HAS GROWN BY 400%, REACHING 146,764 JOBS IN 2024.

Since **2018**, the industry has **increased** its workforce almost **fivefold**, from **29,307** to the current **146,764**. This dramatic increase underscores the strategic importance of photovoltaics not only as an essential technology for energy transition and industrialisation, but also as a **catalyst for creating high-quality jobs**, particularly boosting economic revitalisation in rural areas and generating opportunities throughout the value chain.

Figure 28. Direct employment in the photovoltaic sector from 2014 to 2024.



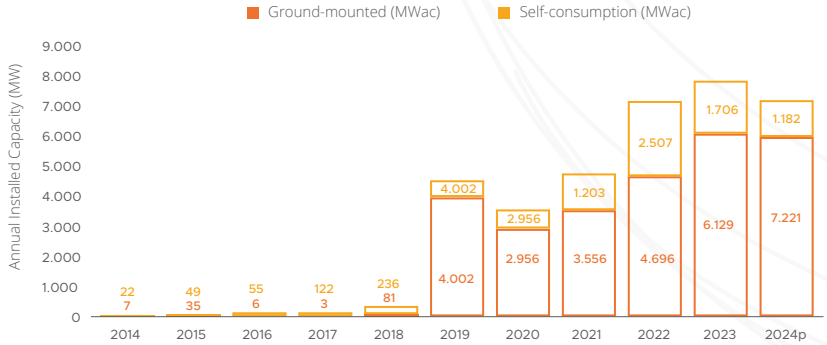
Source: UCLM and UNEF

Since the last turning point in **2020**, direct employment in the photovoltaic sector has almost **doubled**, increasing from **17,568** to over **35,105 jobs** by 2024. After surpassing the **30,000 direct jobs** mark for the first time in 2022, growth has slowed, with an increase of about **12%** from 2022 to 2023 and remaining nearly unchanged in 2024, indicating a stabilisation at peak levels.

3.4.3. Development of photovoltaic solar power capacity in Spain: ground-mounted plants and self-consumption

From 2014 to 2018, the expansion of new photovoltaic capacity in Spain was minimal, with only slight annual increases in both ground-mounted systems and self-consumption installations. A significant shift occurred in **2019 when ground-mounted systems added 4,002 MW** in just one year, **nearly 50 times the growth rate of 2018**, which pushed the national total to **9,694 MW**. Since then, the growth has been steady, with **ground-mounted systems making significant contributions**. **In 2024, they added another 6,039 MW**, bringing the cumulative total to **40,294 MW**. This development has firmly established photovoltaic technology as the leading source of installed capacity within Spain's electricity system.

Figure 29. Annual installed capacity between 2014 and 2024 (MW)

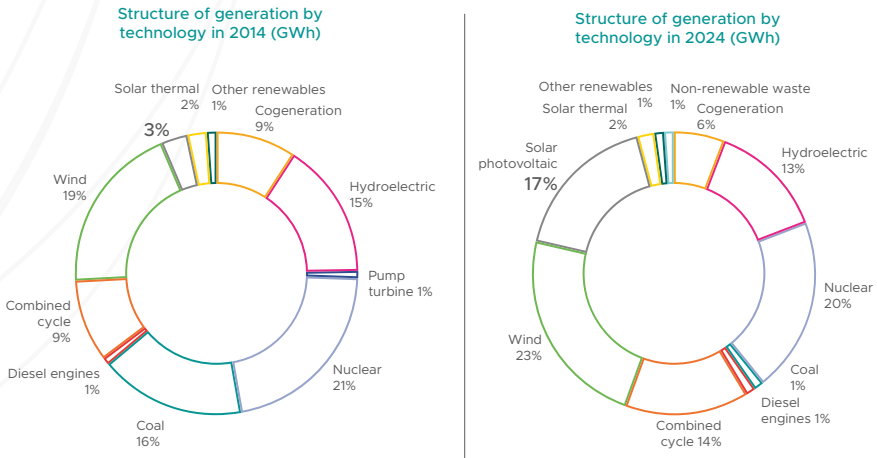


Source: UNEF and REE

Although **self-consumption** has lower absolute volumes, its significance has been growing. Since 2014, it has expanded continuously, **reaching a peak in 2022 with 2,507 MW** installed. This growth then slowed, with **1,706 MW** added in 2023 and **1,182 MW** in 2024. The decline is largely a result of the market stabilising after previous years' high electricity prices and public subsidies drove rapid growth. Despite this deceleration, self-consumption and energy communities are key to decentralising energy generation and fostering public engagement in the energy transition.

TOTAL INSTALLED PHOTOVOLTAIC CAPACITY REACHED 40,294 MW IN 2024.

Figure 30. Generation structure by technology in 2014 and 2024 (GWh).

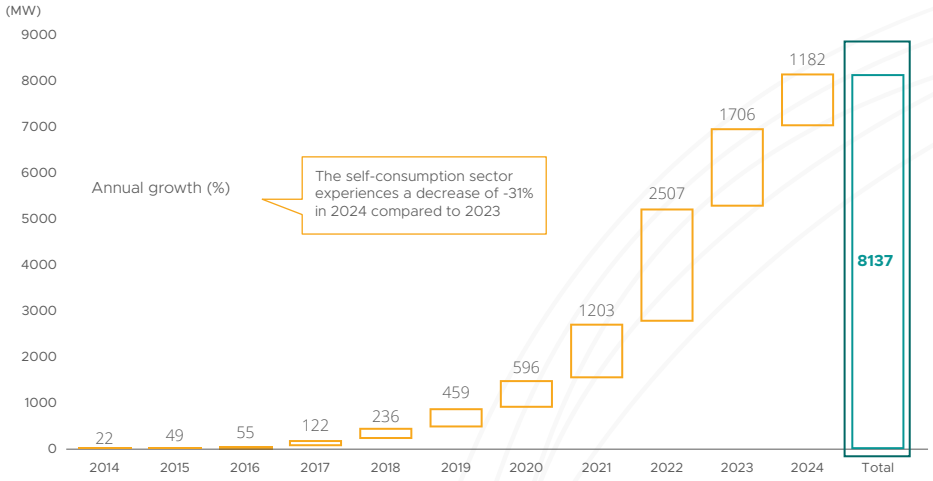


Source: REE

From 2014 to 2024, Spain's **electricity mix** has undergone a significant transformation. Coal generation has almost vanished, dropping from **43,246 GWh** to just **3,030 Gwh** — a 93% decline — and is set to be entirely phased out by 2025 with the closure of the last coal-fired power stations. Meanwhile, **solar photovoltaic output has surged more than fivefold, rising from 8,208 GWh to 44,520 GWh**, making it the third largest contributor to the system. **Wind power** has increased by 19%, and **hydroelectric power** by 26%, despite its inherent variability. Nuclear energy has remained mostly stable, showing a slight decline, while combined cycle power continues to serve as an effective backup. These shifts have **boosted the share of renewables in the energy mix from around 37% in 2014 to over 50% in 2024**, cementing the progress towards a more decarbonised electricity system.

FROM 2014 TO 2024, PHOTOVOLTAIC GENERATION IN SPAIN EXPANDED FIVEFOLD, REACHING 44,520 GWH

Figure 31. Increase in Spanish photovoltaic self-consumption installations (MW).



Source: UNEF

Since 2018, the growth of photovoltaic energy in Spain has largely been driven by ground-mounted installations. Although self-consumption has had a smaller absolute impact, it has become more important as a form of distributed generation. **In 2018, self-consumption accounted for only a small portion of new photovoltaic capacity, but by 2022, it represented nearly a third of the installed capacity that year**.

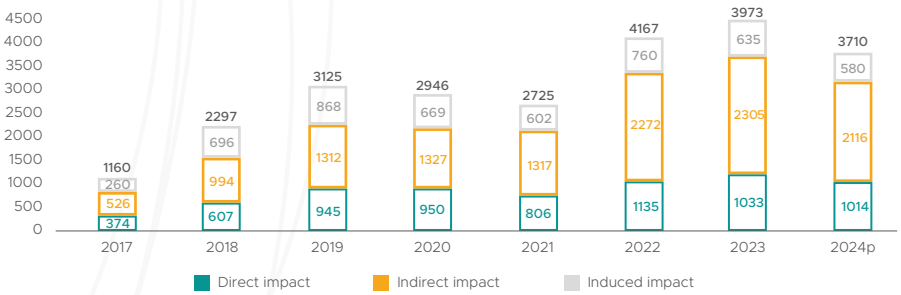
By 2024, **the total capacity from self-consumption still falls short of the 19 GW target for 2030 set by the National Integrated Energy and Climate Plan (PNIEC)**. Reaching this target would require almost **doubling the average annual installation rate** of the past two years. To meet this challenge, strategies need to be revised to speed up deployment. This includes bolstering support for sectors with high potential —such as industry, energy communities, and projects with storage capabilities — and eliminating administrative hurdles that continue to impede expansion.

TO MEET THE 19 GW SELF-CONSUMPTION TARGET BY 2030, AS OUTLINED BY THE NATIONAL INTEGRATED ENERGY AND CLIMATE PLAN (PNIEC), THE ANNUAL INSTALLATION RATE OF THE PAST TWO YEARS MUST DOUBLE.

3.4.4. Trade balance developments

In 2024, the trade balance of Spain's photovoltaic sector remained **positive, with exports** contributing a total economic impact of **€3.71 billion** to GDP, a figure that is **very close to the €3.973 billion recorded in 2023**. While this marks a slight dip from the record high of €4.167 billion in 2022, it still ranks **among the highest levels on record, underscoring the sector's robust presence in international markets**.

Figure 32. Economic impact (GDP) of exports in the Spanish photovoltaic sector in millions of euros.



Source: UNEF

SINCE 2017, THE SECTOR'S EXPORTS HAVE GENERATED MORE THAN €24.1 BILLION.

The **indirect** component remains the most substantial, amounting to **€2.116 billion in 2024, which constitutes 57% of the total impact**. This highlights the value chain's significance and the sector's ability to stimulate economic activity across other areas. **Since 2017, exports have collectively contributed more than €24.1 billion to the trade balance in GDP terms**, with over half stemming from this indirect influence. Over the past decade, the sector has shown **impressive resilience and a swift recovery capability**, even during uncertain times like the Covid-19 crisis, solidifying its role as a key driver of external competitiveness.

3.4.5. Environmental footprint

Photovoltaic solar energy has become a cornerstone of the energy transition, thanks to its ability to both generate emission-free electricity and replace fossil fuels in the energy mix. In 2024, this contribution helped **avoid 17.7 million tonnes of CO_2 equivalent**, comparable to replacing power generated by combined cycle gas turbines. This marks a **20%** increase over 2023, extending the growth trend that began in 2018.

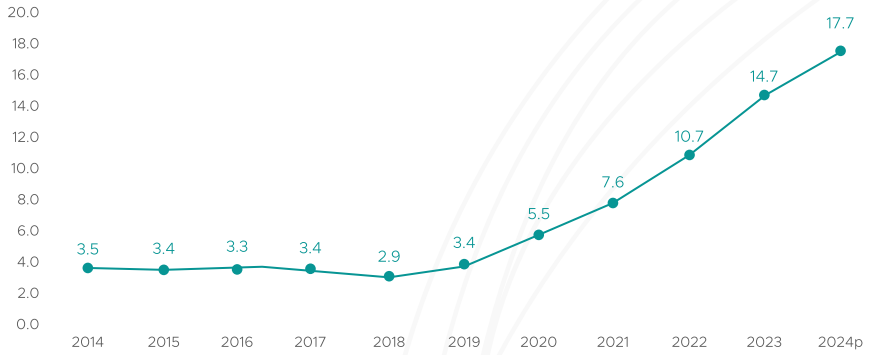
In addition to its daily operations, photovoltaics boasts a **highly favourable environmental profile when considering its entire life cycle**. The carbon emissions from panel manufacturing are **offset within just 6 to 9 months of operation, while the panels' average lifespan of 25 to 30 years** significantly enhances their overall positive impact on emissions reduction.

To maximise this benefit, it is crucial to **increase photovoltaic contributions beyond peak sunlight hours**. This requires deploying **storage** systems that can capture excess energy and release it back into the grid during periods of high demand. Concurrently,

electrifying industry and other energy-intensive sectors will help to structurally cut emissions, boost competitiveness, and enhance energy security against global crises.

IN 2024, PHOTOVOLTAICS PREVENTED 17.7 MTCO$_2$ EQUIVALENT, A 20% INCREASE OVER 2023, BY REPLACING COMBINED CYCLE GENERATION

Figure 33. DIRECT CO2 emissions avoided (cumulative Mte)



Source: UNEF and UCLM

3.5. OUTLOOK

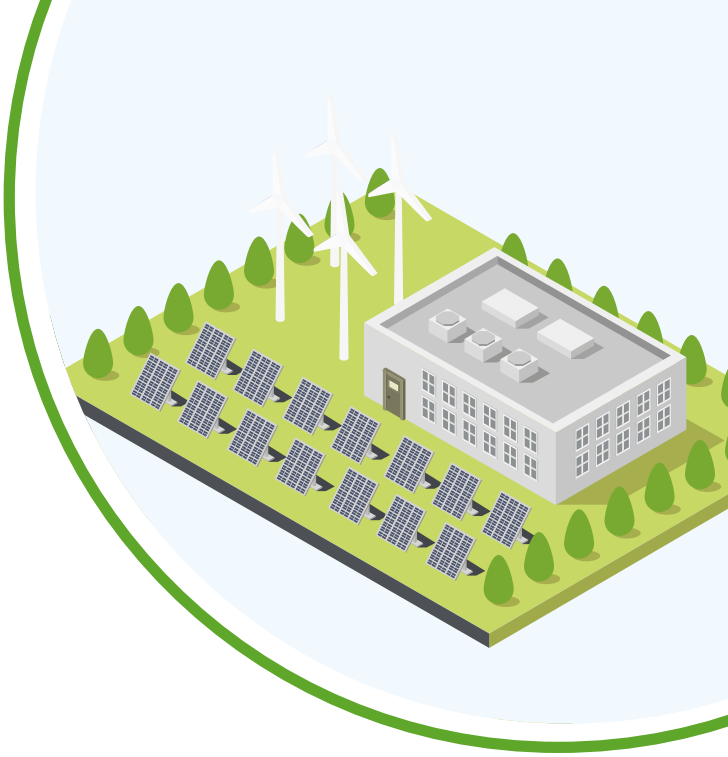
As photovoltaics solidifies its position as the leading renewable technology in the electricity system and becomes increasingly central to the national energy mix, **integrating large-scale storage**, particularly in hybrid ground-mounted plants, **becomes crucial**. Effectively managing surplus energy and shifting solar power to periods of high demand will be key to ensuring system stability and maximising the profitability of installations.

Meanwhile, **self-consumption**, which saw a remarkable surge in 2022, **is beginning to slow in 2023 and 2024**. Keeping up its momentum will require policies that encourage both domestic and industrial investment, streamline administrative processes, and support integration with storage and energy communities. The pace of electrifying the economy, especially in sectors like industry and heavy transport, is slower than desired, which limits the absorption of new renewable capacity and hinders a more substantial reduction in emissions.

On the international front, **the sector faces a more complicated trading environment**, with protectionist and tariff measures potentially impacting the competitiveness of European and national industries. To address these challenges, **it is vital to diversify supply chains and bolster domestic production capabilities** to minimise vulnerabilities and ensure consistent growth.

While photovoltaics is now the most installed generation technology globally and nationally, for its expansion to genuinely reduce emissions and enhance energy independence, it is crucial to promote **electrification in end-use sectors** — such as industry, transport, and climate control. This will enable new renewable generation to effectively replace fossil fuels, making the most of installed capacity and furthering the transition to a cleaner and more efficient energy system.

Are you a renewable energy producer?



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41 STORAGE

4.1. CONTEXT

In 2024, **energy storage remains crucial for advancing renewable energy deployment**. It enhances the management, flexibility, and stability of renewable generation across large-scale, residential, commercial, and industrial sectors.

Large-scale storage is vital for the energy transition. When integrated into photovoltaic plants through hybrid systems, **it allows for the production and storage of low-cost energy while providing flexibility. This approach addresses the duck curve issue, reduces price volatility, aligns production with demand hours, and minimises excess energy waste**. This flexibility not only improves renewable energy use but also stabilises market prices and decreases reliance on backup power plants.

In addition, storage can offer a variety of services to the electricity system, with diverse applications that bring multiple benefits, and it can also be used in a standalone mode. It contributes t**o system balancing** by providing primary, secondary, and tertiary regulation, as well as **voltage control and deviation management**. These services offer an additional revenue stream, enhancing the profitability of these systems. Storage systems also play a vital role in maintaining grid stability, providing synthetic inertia and black start capability during blackouts. These features are increasingly important as traditional synchronous generators are phased out.

The advantages of storage can be extended to residential, commercial, and industrial self-consumption, giving consumers more control over their energy use and reducing electricity bills.

STORAGE CAN ENHANCE GRID STABILITY BY PROVIDING SYNTHETIC INERTIA AND BLACK START CAPABILITIES DURING POWER OUTAGES.

4.1.1. Growing interest in safety

As the development of storage facilities expands, there have been improvements in both regulations and safety systems.

Besides the mandatory regulations in Spain focusing on fire protection and electrical installations, international standards are emerging for the safety, performance, and testing of batteries and electrical equipment. Notable examples include IEC 62133, IEC 62619, UL 9540A, and NFPA 855.

Alongside these regulatory developments, advancements in safety systems are crucial to support their implementation. Prevention and extinguishing systems are organised at various levels: cell, module, pack, rack or container controller, and plant controller. These levels are outlined generally below.

At the pack level, the system monitors each cell's voltage in real-time with millivolt precision and tracks the temperature across the entire cell pack using NTC probes.

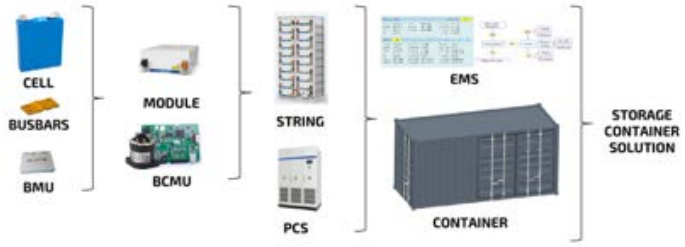
At the next tier, a Battery Management Unit (BMU) manages the signals from each pack within **the rack**. This control system can disconnect the rack electrically from the rest of the system if it detects any issues or anomalies.

At the container level, a Battery Management System (BMS) oversees all the information from the BMU units in each rack and relays it to the plant's other equipment, including inverters and the plant controller. This system can disconnect each rack if the operating parameters go out of range or if the charge state across racks is uneven.

The top tier is the **Energy Management System (EMS)**, a hardware and software platform that coordinates the entire storage plant. It manages interactions with the grid for service planning and synchronises all internal equipment. It also oversees the Power Conversion System (PCS) and can halt operations or disconnect individual equipment if it detects abnormal signals.

The plant is also equipped with **an Uninterruptible Power Supply (UPS)**, which provides limited autonomy during a grid failure, allowing monitoring to continue even if there is a power loss.

Figure 34: Internal components of a battery



These measures will ensure the safe and sustainable development of energy storage projects.

4.2. INTERNATIONAL FRAMEWORK

4.2.1. International analysis

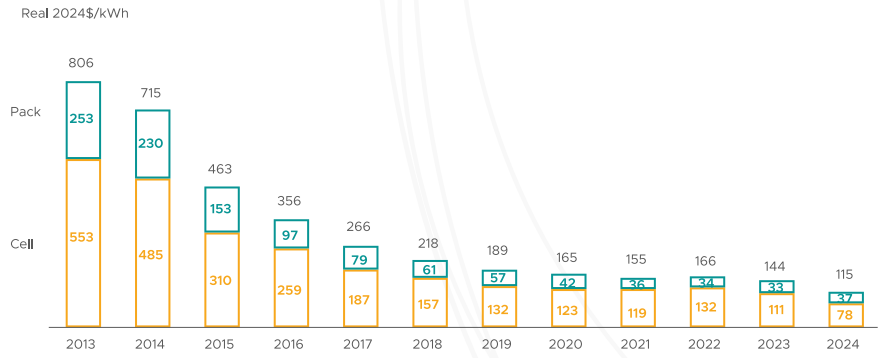
4.2.1.1. Prices in 2024

In 2024, battery prices saw their largest annual decline since 2017. The cost of lithium-ion battery packs dropped by 20% from 2023, **hitting a record low of $115/kWh**.[2]. Several factors contributed to this decrease: overcapacity in cell production, economies of scale, low prices for metals and components, a shift towards cheaper lithium iron phosphate (LFP) batteries, and a slowdown in the growth of electric vehicle sales. This year's drop in battery cell prices outpaced the decrease in battery metal prices, indicating pressure on manufacturers' profit margins. The $115/kWh figure represents a global average, with significant price variations across different countries and application areas.

Over the past two years, battery manufacturers have significantly increased their production capacity, anticipating a rise in demand from the electric vehicle and stationary storage sectors. Currently, production capacity stands at 3.1TWh globally, which is equivalent to 2.5 times the demand in 2024.

IN 2024, THE PRICE OF LITHIUM-ION BATTERY PACKS DROPPED BY 20%, REACHING A RECORD LOW OF $115/KWH

Figure 35: Breakdown of the weighted average price by cell volume and lithium-ion battery pack



Source: BloombergNEF. Note: Historical prices have been updated to reflect actual 2024 dollars. The weighted average value of the survey includes 343 data points for passenger cars, buses, commercial vehicles and stationary storage systems.

Regionally, battery pack prices were lowest in China at $94/kWh. In the US and Europe, prices were 31% and 48% higher, respectively, due to the relative immaturity of these markets, higher production costs, and lower volumes.

2 According to data reported by BloombergNEF (BNEF)

4.2.1.2. Installed capacity

In 2024, the deployment of grid-connected energy storage systems (BESS) increased by 53% year-on-year, **reaching 205 GWh installed globally**, surpassing expectations. Over 160 GWh of this total came from grid-scale systems, with 98% being lithium-ion.

GRID-CONNECTED BESS SYSTEMS SAW A 53% INCREASE GLOBALLY IN 2024, WITH 205 GWH INSTALLED.

The global grid-connected BESS market expanded by 68%, rising from 96 GWh to 160 GWh. China accounted for 67% of these deployments, driven by provincial mandates and record-low prices for cells and systems. The US and Canada were second with around 40 GWh, half of which were installed in California. In Europe, Latin America, and the Asia-Pacific region (excluding China), installations doubled.

Seventeen large-scale projects with more than 1 GWh capacity were commissioned: 11 in China, 5 in the US, and 1 in Saudi Arabia. In 2023, only 4 projects exceeded this capacity.

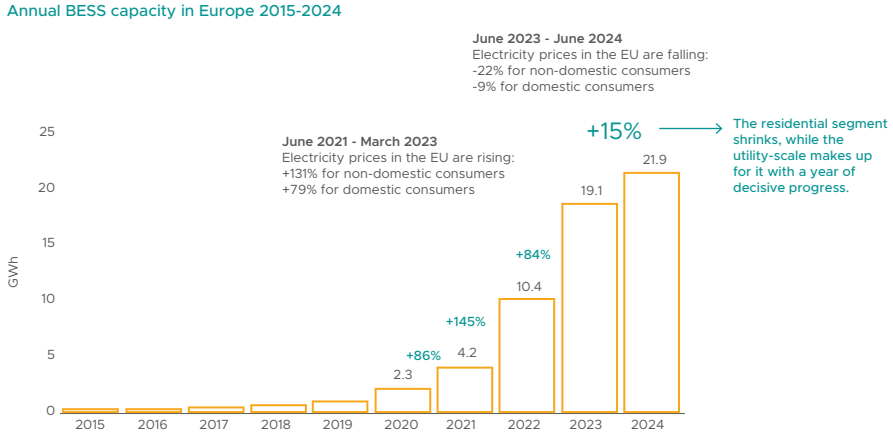
More than 40 GWh were added in the off-grid segment, largely in residential and commercial and industrial (C&I) markets. In Europe, the residential market stabilised due to electricity prices and subsidy reductions, while in China, behind-the-meter storage drives 39% of the C&I segment.

4.2.2. European analysis

4.2.2.1. Installed capacity

In 2024, **Europe installed 21.9 GWh of battery energy storage systems (BESS)**, marking a decade of record-breaking growth. The EU-27 accounted for 18.5 GWh of this, representing 85% of the European total.

Figure 36: Annual BESS capacity in Europe (2015-2024)



Source: Solar Power Europe

However, **annual growth slowed considerably in 2024** to 15%, after nearly doubling on average in previous years (with 145% in 2022). This slowdown was expected since the surge from 2021 to 2023 was primarily driven by the residential segment in response to high electricity prices.

In 2024, with electricity prices stabilising, the withdrawal of key subsidies, and a cooling residential solar market, demand for home batteries dropped by 11%.

IN THE EU-27, 18.5 GWH WERE INSTALLED, ACCOUNTING FOR 85% OF EUROPE'S TOTAL

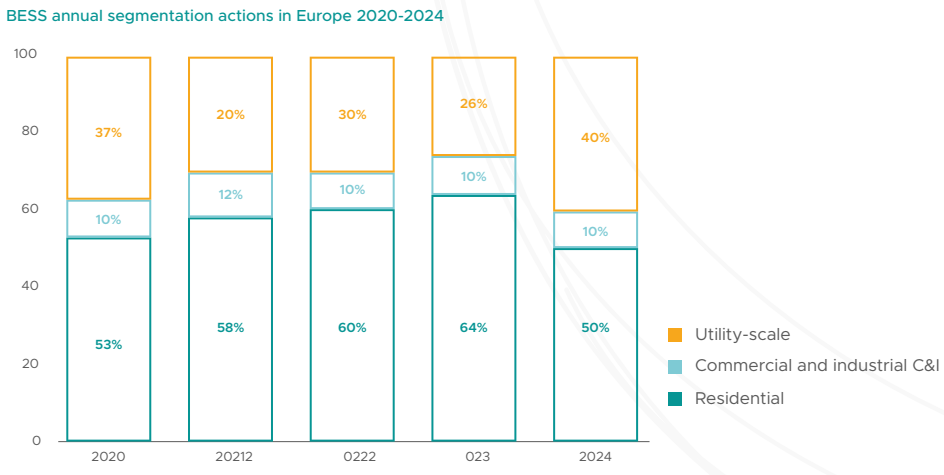
Despite this, **the residential sector remained the largest**, with nearly 11 GWh installed, though it lost ground to the utility-scale sector, which grew by 79% to nearly 9 GWh, marking a pivotal moment for large-scale storage in Europe.

The **commercial and industrial (C&I) segment also expanded**, but at a slower pace of 17%, reaching 2.2 GWh, limited by lower electricity prices, reduced support, and minimal flexibility revenues.

In terms of market share, the residential segment decreased from approximately 64% in 2023 to around 50% in 2024. The utility-scale share increased from roughly 26% to 40%, while C&I remained stable at about 10%.

Overall, 2024 marked a turning point for energy storage in Europe. **Growth slowed**, with the residential market receding, but this was balanced by strong momentum in the utility-scale sector, indicating a structural shift in the industry's dynamics.

Figure 37: Annual share by segment of BESS in Europe (2020-2024)



Source: Solar Power Europe

Total battery storage capacity in Europe is still growing rapidly, but **2024 marked a significant change: a shift from the dominance of residential installations to a greater focus on large-scale batteries**.

BESS CAPACITY IN EUROPE SURPASSED 60 GWH IN 2024, A 56% RISE FROM 2023 AND 200 TIMES MORE THAN IN 2015.

By the end of 2024, Europe's installed BESS capacity had surpassed 60 GWh, a 56% increase from 2023. Over the past decade, capacity has increased 200 times, from just 300 MWh in 2015 to more than 60 GWh in 2024.

4.2.2.2. European regulation

The European Union views energy storage, particularly through batteries, as crucial for the energy transition. It facilitates the integration of renewables, enhances energy security, reduces reliance on fossil fuels, offers network services, and improves system flexibility.

Key European regulations and plans include:

- **- The Renewable Energy Directive (RED III)** , which mandates that Member States integrate flexibility, including storage, into their systems. It also raises the renewable energy target to 42.5% by 2030 and calls for the removal of barriers to storage.

- **- The Regulation on the design of the electricity market,** , approved in April 2024, introduces reforms to support flexibility and storage. This includes contracts for differences open to hybrid systems, incentives for investment in storage, national flexibility needs assessments, and the promotion of capacity markets, among other measures.

- **The European Commission's flexibility package,** currently under development, aims to coordinate national strategies, establish country-specific storage targets, implement measures against double pricing, and eliminate obstacles. Although not yet formally adopted, the European Commission started work in 2024 on an EU Energy Storage Action Plan.

- **The 2023 Battery Regulation** sets standards for environmental, safety, and recycling requirements and introduces criteria for carbon footprint, recycled content, and digital labelling.

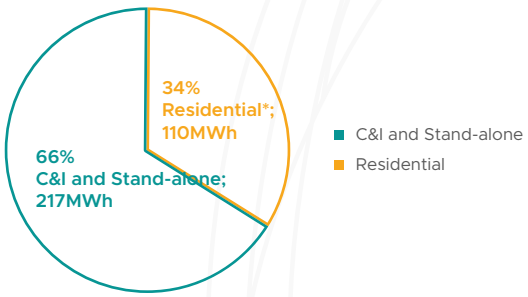
Despite these advances, some barriers remain that European regulations have yet to adequately address, such as the lack of regulatory harmonisation and the absence of a specific, coordinated plan for the widespread deployment of storage.

4.3. NATIONAL FRAMEWORK

4.3.1. Behind-the-meter storage

Behind-the-meter (BTM) storage systems are battery installations located in homes, businesses, or industries, connected on the consumer side rather than to the central grid. Their primary purpose is to store locally generated energy, such as that from solar panels, or to charge from the grid during off-peak hours for use when energy is more costly or less available. **BTM storage reduces reliance on the grid, enhances self-consumption, lowers electricity costs, and supports overall system stability**.

Figure 38. Storage installed in 2024



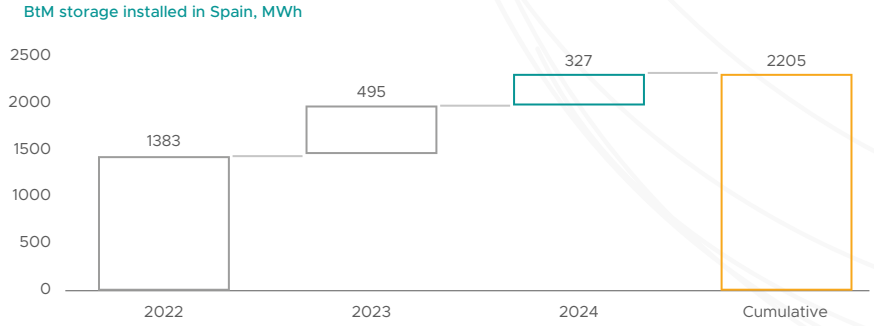
(*) Does not include off-the-grid Source: UNEF (C&I: Commercial and industrial)

According to UNEF's annual internal studies, 327 MWh of new BTM storage was installed in 2024, bringing the cumulative total to 2,205 MWh since 2022. This represents a **34% drop compared to 2023**, when 495 MWh was installed, indicating a slowdown in installation rates. This reduction mirrors the trend seen in self-consumption installations.

In 2024, 26% of new grid-connected residential self-consumption setups included batteries, amounting to a capacity of 110 Mwh. Additionally, there is increasing interest in BTM storage within the commercial and industrial sectors.

IN 2024, 327 MWH OF BEHIND-THE-METER STORAGE WAS ADDED, BRINGING THE CUMULATIVE TOTAL TO 2,205 MWH SINCE 2022.

Figure 39. Behind-the-meter storage installed in 2024



Source: UNEF

After analysing the data and the observed decline, measures are still being pushed to promote savings in self-consumption facilities. This includes exempting facilities that inject less than 15kW from processing, simplifying procedures for up to 500kW installations, and developing the role of the independent aggregator to facilitate the participation of behind-the-meter storage in all markets.

26% OF NEW RESIDENTIAL SELF-CONSUMPTION INSTALLATIONS CONNECTED TO THE GRID IN 2024 INCLUDED STORAGE SYSTEMS

Additionally, **distributed storage**, which is not necessarily linked to generation, is being given importance. It is explicitly included in the regulations and is to be treated as equivalent to self-consumption, aligning with proposals developed by UNEF.

4.3.2. Large-scale storage

Large-scale energy storage is crucial for maintaining the security, flexibility, and resilience of the electricity system as renewable energy sources become more prevalent. Hybrid solutions that combine storage with solar plants help optimise renewable output, minimise waste, and ensure a more stable and predictable supply. Meanwhile, **stand-alone facilities**, which are connected directly to the grid without any associated generation, provide vital services such as frequency balancing, managing peak demand, and maintaining strategic reserves. Both approaches complement each other and are vital for integrating more renewable sources, reducing emissions, and ensuring that the energy system remains reliable, efficient, and sustainable.

4.3.2.1. Requests for stand-alone and hybrid access to REE

Despite the limited number of storage facilities operating by the end of 2024 (11 MW in the distribution network), data from Red Eléctrica de España (REE) regarding access and connection requests indicates a growing interest in deploying storage facilities.

At the time of the latest report's publication, there were **applications for 8,318 MW of storage capacity in distribution networks**, with 4,298 MW already granted access and connection permits, meaning they have passed technical evaluations and been accepted by the system operator. **For the transmission network, applications totalled 10,763 MW**, with 7,456 MW approved.

Twelve months later, access and connection capacity for storage facilities has increased to 9,531 MW with permits granted, and 16,564 MW with permits pending.

4.3.2.2. Challenges in administrative and environmental procedures

One major obstacle to deploying large-scale storage is the **administrative barriers within the process**. Although these issues began to be identified in 2023, by 2024 there remains legal uncertainty and an unclear regulatory framework for storage systems.

Notable among these barriers are the change of the responsible authority and the need to restart the process for hybridisation projects. In the first case, adding storage modules that increase the total power above 50 MW transfers jurisdiction from the regional government to the Ministry. This shift **requires starting the procedure anew and poses a risk of missing administrative deadlines**. In the second case, the entire process must be restarted—regardless of the power—if storage modules are added before obtaining the Administrative Construction Authorisation (AAC) or even the Operating Authorisation (AAE). This interpretation stems from a narrow reading of Article 115 of Royal Decree 1955/2000, which deems the inclusion of storage a substantial modification.

In the environmental domain, a key barrier to **hybridisation** is the demand for a new environmental assessment of projects that have already completed this step for the generation component. This duplication of procedures considerably extends processing times, even when no significant additional impacts are introduced.

A significant barrier for stand-alone installations is the absence of explicit provisions for applying for a declaration of public utility for evacuation lines. Additionally, issues have arisen concerning land use, stemming from municipal regulations and the lack of regional or state-level guidelines. This has led some municipalities to make land-use decisions without adequate understanding of the technology involved.

4.3.2.3. Profitability, market participation and capacity mechanism

The viability of storage systems relies on a **revenue stacking** model, which allows them to diversify and capture income from multiple markets. Ensuring these markets are compatible with each other and allowing access to diverse revenue streams will be crucial for their development. While storage systems already participate in the daily, intraday, and balancing services markets, the introduction of a capacity mechanism is one of the most anticipated developments for 2024.

Although the outcome of the public hearing and information process is not expected until 2025, **2024 marks the beginning of**

this process for the draft order establishing a capacity market in the peninsular electricity system, aimed at supporting the security of electricity supply. This public consultation has been highly anticipated within the sector, given the lack of updates since the first draft was announced in 2021. It signifies a significant step forward in integrating storage systems into the electricity market and enhancing their profitability.

The **capacity mechanism** is a vital tool in electricity markets, designed to ensure the security of energy supply, particularly in scenarios with high penetration of renewable energy. Without implementing a capacity mechanism, the peninsular electricity system is expected to encounter stress situations and coverage issues as it struggles to meet projected demand across various timeframes. This mechanism guarantees that there are adequate resources to meet electricity demand during critical times, including consumption peaks and periods of low renewable generation.

Over the past three years, the sector has received signals suggesting that the activation of the capacity market is imminent. In November 2023, the system operator published the National Resource Adequacy Analyses (NRAA), which complement the 2022 European Resource Adequacy Assessment (ERAA). Both reports highlight coverage risks, reinforcing the necessity of implementing the newly approved capacity mechanism.

IN 2024, THE CAPACITY MECHANISM, CRUCIAL FOR MAKING STORAGE VIABLE, WAS OPENED FOR PUBLIC CONSULTATION

One of the main **unresolved issues** is how the capacity mechanism will operate for the participating contractors. The mechanism requires participants—such as energy producers, storage facility owners, consumers, and demand aggregators—to offer reliable capacity to ensure system coverage. However, questions remain about the management of activations: how far in advance will system stress situations be identified, and when will contracted assets be alerted to provide the committed capacity. There is also uncertainty about how the capacity mechanism will interact with other balancing markets, such as secondary regulation and replacement reserve (RR).

Another concern for the photovoltaic sector is the **involvement of non-renewable emission technologies in these auctions**. An emissions limit is set for bidders, which might allow combined cycle plants and other non-renewable technologies to win. This is compounded by uncertainty around hybridisation with storage systems, as it is unclear how emissions will be calculated when batteries are charged from the grid.

Although there are questions surrounding the capacity mechanism, the sector eagerly anticipates this process. It brings hope for the advancement of storage systems, and UNEF will closely monitor its progress.

4.3.2.4. Launch of the storage seal of excellence

One of UNEF's key initiatives to promote sustainable and safe storage development is the introduction of the **UNEF Storage Seal of Excellence**.

This certification serves as a societal assurance, aiming to foster good practices and counter misinformation about energy storage. Derived from the UNEF Sustainability Seal and specifically adapted for this technology, it has been developed in collaboration with experts across the entire value chain.

The criteria are categorised into five areas: socio-economic impact, environmental impact, industrial safety, governance, and circular economy. Among other standards, they outline best practices for minimising landscape and noise impact, engaging with local stakeholders early on, and ensuring fire protection.

4.3.2.5. Calls for storage grants

Public grants for energy storage have been crucial in promoting this technology and establishing it as a key component of the energy transition.

These grants make more projects viable by reducing investment costs, overcoming financial barriers, and providing certainty to developers and industries. They also drive technological innovation, **boost domestic battery manufacturing**, and help integrate renewable energy, thereby enhancing energy security and stabilising the electricity system.

In 2024, significant progress was made with the conclusion of the grant call for innovative stand-alone electricity storage projects under the PERTE ERHA, funded by NextGenerationEU, which allocated a budget of €150 million. This resulted in awards for a total of 45 projects across different autonomous communities, amounting to nearly 780 MW of capacity.

THE PERTE ERHA INITIATIVE FOR STAND-ALONE STORAGE WAS LAUNCHED IN 2024

UNEF has been heavily involved in extending the implementation deadlines beyond April 2026, working with both IDAE and European bodies to ensure these innovative projects are successfully completed and receive the necessary support.

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4.4. HYDROGEN

Renewable hydrogen plays a crucial role in the energy transition by enabling the decarbonisation of sectors that are hard to electrify, such as heavy industry and maritime transport. It also allows for the seasonal storage of large volumes of renewable energy.

For the photovoltaic sector, hydrogen presents a **strategic opportunity**. Surplus solar generation can be used to produce hydrogen through electrolysis, turning energy that would otherwise be fed into the grid at low or zero prices into a valuable asset. This helps stabilise revenues and diversify markets. Promoting green hydrogen also strengthens the local value chain, bolsters national industry, creates skilled jobs, and reinforces Spain's leadership in the renewable energy sector.

4.4.1. International framework

In recent years, renewable hydrogen has become one of the primary drivers for decarbonising the European and global economy. The European Union views this energy source as crucial for reducing emissions in sectors that are hard to electrify, such as heavy industry and maritime and air transport, while also utilising surplus solar and wind energy production. Within this context, the European Green Deal and the REPowerEU plans have made green hydrogen a focal point of their energy strategy. They aim to achieve at least **10 million tonnes of domestic renewable hydrogen production annually by 2030**, with an additional 10 million tonnes to be imported from other countries.

Internationally, major powers such as the United States, Japan, South Korea, and Australia have launched ambitious national strategies with clear targets for deploying electrolysers and distribution networks. By 2024, there were over 1,000 active green hydrogen projects worldwide, with a projected electrolysis capacity exceeding 150 GW by 2030, according to the International Energy Agency (IEA) and the Hydrogen Council. While the pace of implementation has been slower than initially planned, **there has been a noticeable acceleration in projects reaching the final stages of development and construction**. This progress is driven by clearer regulatory frameworks and increased public investment commitments.

IN 2024, THERE WERE OVER 1,000 ACTIVE GREEN HYDROGEN PROJECTS WORLDWIDE

Table 11: Projects selected in the first auction of the European Hydrogen Bank

Project	Coordinator	Country	Volume offered (kt_H2/ 10 years)	Capacity offered (MWe_ Mega watts electric)	Projected GHG avoidance (kt_CO2/10 years)	Offered price (EUR/kg)
eNRG Lahti	Nordic Ren-Gas Oy	Finland	122	90	836	0.37
El Alamillo H2	Benbros Energy S.L.	Spain	65	60	443	0.38
Grey2Green-II	Petrogal S.A.	Portugal	216	200	1477	0.39
HYSENCIA	Angus	Spain	17	35	115	0.48
SKIGA	Skiga	Norway	169	117	1159	0.48
Catalina	Renato Ptx Holdco	Spain	480	500	3284	0.48
MP2X	Madoquapower 2x	Portugal	511	500	3494	0.48

Source: European Commission

For the European Union, a significant milestone was the launch of the **European Hydrogen Bank** in 2023. This tool is designed to bridge the cost gap between renewable and fossil-based hydrogen. In April 2024, the **first pilot auction** allocated €720 million to seven projects, aiming for a total production volume of 1.58 million tonnes over ten years, with subsidised prices reaching up to €4.50/kg. Notably, **three Spanish projects received** over €263 million, reinforcing Spain's status as a European leader in this transition.

This initiative is further supported by the **IPCEI** (Important Projects of Common European Interest) **programmes**, which permit the granting of state aid for strategic and transnational projects. In total, the two major IPCEI initiatives—Hy2Tech (focused on technology and innovation) and Hy2Use (focused on infrastructure and industrial applications)—have mobilised over €18 billion in both public and private investment, supporting more than 50 industrial projects across Europe. These initiatives, along with associated national programmes, are driving the deployment of large-scale electrolysers, hydrogen transmission infrastructure, and production centres connected to industrial hubs.

THE HY2TECH AND HY2USE IPCEIS HAVE LEVERAGED MORE THAN €18 BILLION IN INVESTMENTS AND SUPPORTED OVER 50 INDUSTRIAL PROJECTS ACROSS EUROPE

The drive for renewable hydrogen at both the European and international levels is well underway, with hundreds of projects in the design or construction phase, a robust network of public funding, and a regulatory framework progressing towards harmonisation and the recognition of guarantees of origin. **The current challenge is to accelerate implementation, reduce costs, and establish a competitive common market** that enables cross-border

exchange and integrates hydrogen effectively into the future energy mix.

4.4.2. National framework

A key area of national progress in hydrogen involves the development of **infrastructure and networks**.

In 2024, Spain's hydrogen transmission network expanded by 2,600 km, representing 12% of the new 21,000 km developed across Europe. This positions Spain as a leading force in green hydrogen in Europe.

The **H2Med corridor project** is a significant transnational initiative involving Portugal, Spain, France, and Germany, aiming to connect the Iberian Peninsula's hydrogen networks with those of north-western Europe. Spain and Portugal have developed two sections of a 248 km hydroduct project linking Portugal and Zamora, with a capacity of 0.75 million tonnes per year. Additionally, construction has progressed on an underwater pipeline connecting Barcelona and Marseille, with a capacity of 2 million tonnes per year.

SPAIN EXPANDED ITS HYDROGEN NETWORK BY 2,600 KM IN 2024, ACCOUNTING FOR 12% OF THE TOTAL IN EUROPE

Nationally, the **hydrogen valleys** are notable integrated territorial initiatives that support the coordinated growth of the entire renewable hydrogen value chain within specific regions. Hydrogen ecosystems integrate production via electrolysis powered by renewable energy, alongside storage, distribution, and diverse end uses in sectors like industry, transportation, and electricity generation.

These initiatives foster cooperation between producers and consumers, reduce costs through economies of scale, and enable the sharing of capital-intensive infrastructure—such as high-capacity electrolysers, local distribution networks, and refuelling stations. They also stimulate local demand in the sector's early development phases.

In Spain, hydrogen valleys play a crucial role in the **2020 Hydrogen Roadmap** and the Strategic Projects for Economic Recovery and Transformation (PERTE) for Renewable Energy, Renewable

Hydrogen, and Storage (**PERTE ERHA**). Significant progress has been made in 2024.

Figure 40: Main hydrogen valleys in Spain

Source: Energías renovables

The Government, in coordination with the European Union, has allocated over **€1.2 billion in direct funding** to advance hydrogen valleys and large-scale projects. As part of the IPCEI Hy2Use initiative (July 2024), seven major projects, with a combined electrolysis capacity of 652 MW, have been approved across five key regions: Andalusia, the Basque Country, Asturias, Castile-La Mancha, and Murcia. In 2024, Galicia announced a hydrogen valley in A Coruña, involving an investment of €170 million to produce renewable hydrogen and supply industries at the port and the A Grela industrial estate.

IN 2024, SEVEN PROJECTS WITH AN ELECTROLYSIS CAPACITY OF 652 MW WERE APPROVED

Hydrogen valleys are a cornerstone of the Spanish and European strategy to establish a competitive renewable hydrogen market. Beyond reducing emissions, they aim to create skilled local jobs, attract private investment, and enhance the country's energy independence. For the photovoltaic sector and other renewable sources, these valleys provide opportunities to monetise surplus energy, secure stable electrolysis supply contracts, and diversify demand outside the conventional electricity grid.

Currently, **361 renewable hydrogen projects**[3] are in various stages, from research to commercial deployment. Of these, 167 are commercial projects, which together could achieve a total electrolysis capacity of 23 GW if fully realised.

3 According to the database of the Spanish Renewable Hydrogen Association (AeH2)

5 | PHOTOVOLTAIC INDUSTRY

This chapter was prepared in collaboration with FOTOPLAT, the Spanish Photovoltaic Technology Platform.

5.1. CURRENT STATE OF PHOTOVOLTAIC TECHNOLOGIES

This section examines the current state of technological development and the key trends in innovation within the photovoltaic solar energy sector, including its various components and applications.

BY LATE 2024, MONOCRYSTALLINE SILICON TECHNOLOGIES DOMINATED THE GLOBAL PHOTOVOLTAIC MODULE MARKET, HOLDING A 98% SHARE.

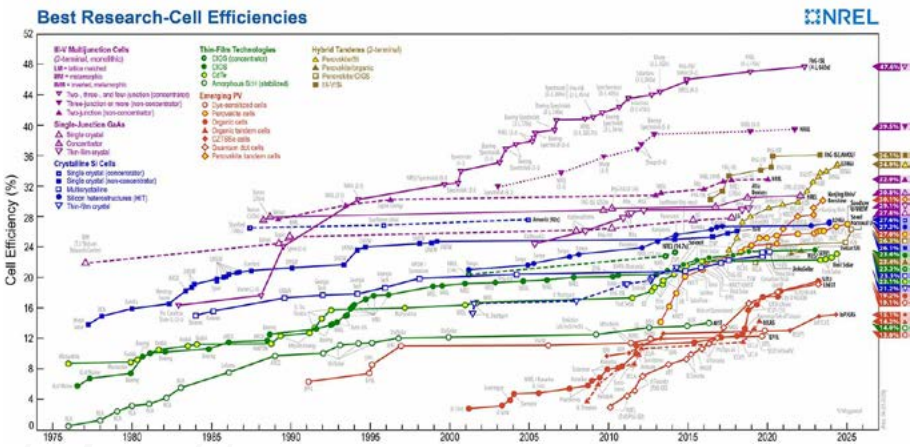
Photovoltaic cells: semiconductor materials

Crystalline silicon (c-Si) continues to be the leading material in photovoltaic cell production. By the end of 2024, this technology comprised nearly 94% of the global market, with other alternatives contributing just 2%. Within this category, **monocrystalline silicon cells lead in efficiency**, holding a record of 26.1% (see Figure 41), a figure unchanged over the past seven years. Conversely, silicon heterojunction (SHJ) cells have made significant advancements, achieving 27.3% efficiency in 2024.

Cells based on **perovskites have gained traction due to their high efficiency** — comparable to silicon — simplified manufacturing processes, and considerably lower production costs, which support the development of more versatile modules. The current laboratory record for a perovskite cell is 27% (see Figure 41). Furthermore, pairing them with silicon cells in tandem configurations allows for surpassing the theoretical Shockley-Queisser limit of 33.7%, achieving an efficiency of 34.9% in 2024, according to NREL data (see Figure 41). These tandem architectures not only optimise energy conversion but also provide greater durability compared to conventional silicon technologies, establishing perovskites as one of the most promising materials for the next generation of modules.

Other emerging options include organic photovoltaic cells, noted for their lightness, flexibility, and partial transparency, as well as their simple manufacturing processes and lower costs, features they share with thin-film technologies. Although their efficiency has not yet reached that of crystalline silicon cells, significant advancements have been made, achieving 19.2% in laboratory settings (see Figure 41).

Figure 41. Laboratory efficiency trends of various photovoltaic cells.
Source: NREL



Photovoltaic module manufacturing processes

PEROVSKITE CELLS ARE NOTABLE FOR THEIR POTENTIAL TO USHER IN A NEW GENERATION OF SOLAR MODULES THAT ARE MORE EFFICIENT, VERSATILE, AND COST-EFFECTIVE.

In recent years, significant advances have been made in photovoltaic module production processes, particularly in cell interconnection, with innovations focused on enhancing energy efficiency and reducing costs. For crystalline silicon modules, manufacturing follows a well-defined sequence:

1. Reduction, purification, and crystallisation of silicon.
2. Forming ingots.
3. Cutting the ingots into wafers.
4. Producing photovoltaic cells from these wafers.
5. Assembling the modules by integrating cells and complementary components.

Crystalline silicon remains the dominant material in the global market. In 2024, the photovoltaic industry continued its robust growth, with Asia—and China, in particular—serving as the centre of global production. Comparatively, the United States' market share was around 2.2%. In 2023, the minimum price of modules reached a historic low of €0.12/Wp, a result of capacity growth significantly outpacing demand. This downward trend persisted in 2024, with prices dropping below €0.09/Wp.[1]

One of the most significant innovations is the PERC (Passivated Emitter and Rear Contact) cell, which enhances the efficiency of monocrystalline modules. This is achieved through a reflective layer on the back that redirects initially unabsorbed light back to the semiconductor. In 2025, manufacturers continued to invest in new cell formats and upgraded PERC lines to optimise wafer design and increase efficiency, already achieving 23.8%. Projections indicate that this technology could average 23.8% efficiency by 2027 and exceed 24% in the following decade [2].

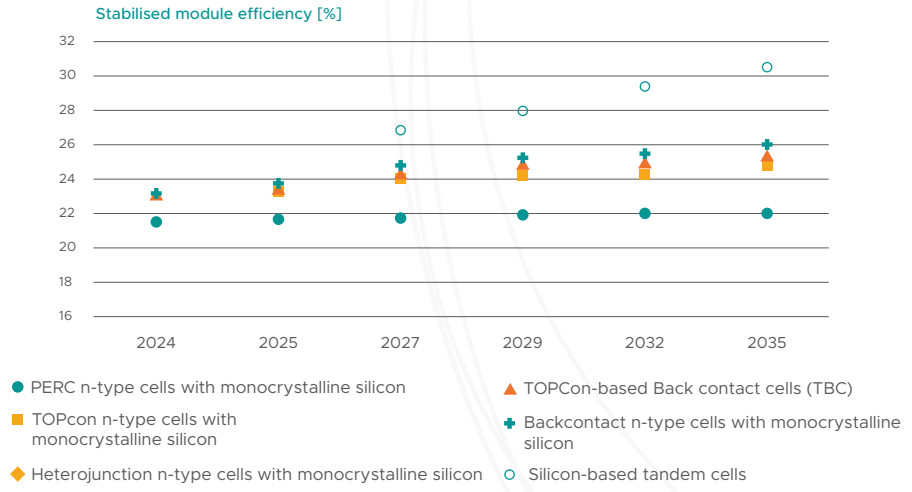
1 Trends in photovoltaics applications 2024 (IEA), (2023 Results)
2 International Technology Roadmap for Photovoltaics (ITRPV), 2024 (2023 Results)

TOPCon (Tunnel Oxide Passivated Contacts) technology represents the natural evolution of PERC. It has the advantage of being producible on the same production lines, which minimises industrial conversion costs. Its efficiency potential is substantial, with estimates reaching around 24.7% by 2035 (see Figure 42).

More advanced still are the **modules with back-contact cells**, which avoid optical losses from front contacts by placing all electrical connections on the rear side. Noteworthy variants include all-back-contact and IBC (Interdigitated Back Contact) cells, which employ interdigitated structures to improve charge collection.[3]

Tandem modules, which use double-junction cells based on heterojunctions or material combinations with different crystalline structures, offer efficiencies far superior to conventional ones by making fuller use of the solar spectrum. Each subcell is designed to absorb specific wavelength ranges, enabling these modules to comfortably surpass the theoretical Shockley-Queisser limit for single-junction cells. This technology is poised to be a key focus for the next generation of photovoltaic modules.

Figure 42. Module efficiency trends in mass production with different technologies
Source: ITPRV, 2025

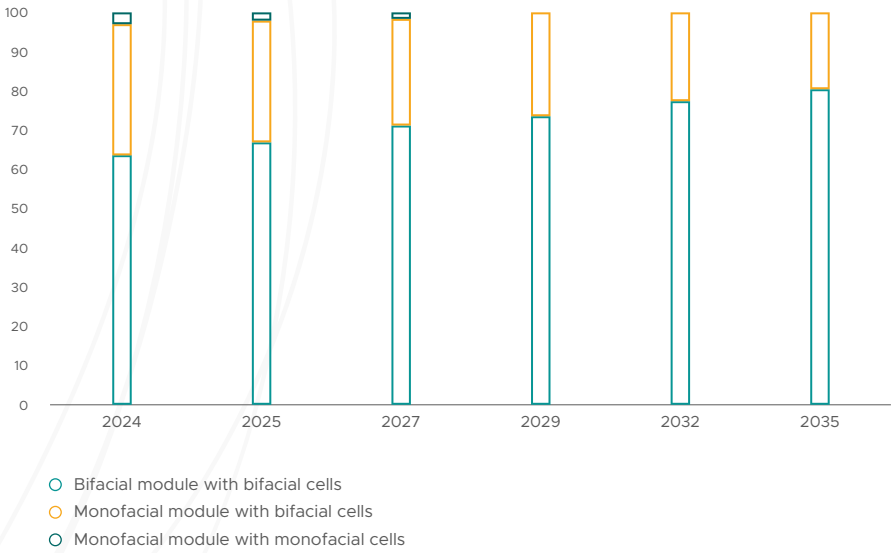


In recent years, bifacial photovoltaic modules have become increasingly significant in the market due to their ability to capture solar radiation from both sides. This feature allows them to use not only direct sunlight but also diffuse and ground-reflected radiation, leading to increased electricity generation and greater overall system efficiency. Additionally, this technology enables more efficient use of space, particularly in large-scale plants.

According to the International Technology Roadmap for Photovoltaics (ITRPV), **bifacial modules are expected to account for around 66% of the global market share by 2025**. Projections suggest that this percentage could rise to 80% in the coming years (see Figure 43).

3 https://www.pveducation.org/pvcdrom/manufacturing-si-cells/rear-contact-solar-cells

Figure 43. Market share of mono and bifacial modules



Source: ITPRV, 2025

Solar trackers

BIFACIAL MODULES STRENGTHENED THEIR MARKET POSITION, CAPTURING 66% OF THE MARKET BY 2025

Solar tracking systems enhance the efficiency of photovoltaic plants by adjusting the orientation of the modules in real time to follow the sun's position, thereby optimising the angle of incident radiation. This approach boosts electricity generation by 10% to 20% in single-axis systems, with even greater benefits when paired with bifacial modules. To operate continuously and stably, these systems need to perform reliably across various environmental conditions and under variable loads. A key advantage is their ability to maximise energy production during times when the solar angle is low, such as early morning and late afternoon.

There are two primary types of solar trackers:

- Single-axis trackers, which align the modules in an east-west direction.
- Dual-axis trackers, which adjust both tilt and orientation based on the time of year.

While dual-axis systems require a higher investment, they provide additional efficiency benefits, particularly in regions with significant seasonal variability.

This segment has grown notably alongside the global expansion of photovoltaics. In 2024, single-axis systems captured about 90% of the tracker market. Nonetheless, dual-axis systems are anticipated to become more prevalent in the coming years. Over the last financial year, North America led the market with roughly 30% of the share, while Europe is poised for significant growth between 2024 and 2030.[4]

Emerging trends focus on designs that enhance reliability and

4 https://www.precedenceresearch.com/solar-tracker-market

performance by making more efficient use of materials, thereby reducing costs and improving environmental impact based on life cycle analysis (LCA) criteria. Additionally, the integration of intelligent control and operation systems, along with increased compatibility with bifacial cells and other advanced technologies, is gaining traction.

IN 2024, SINGLE-AXIS SYSTEMS MADE UP 90% OF THE SOLAR TRACKER MARKET.

Inverters

The latest generation of inverters from leading brands achieve **efficiency levels exceeding 98%**, making them crucial for maximising the performance of photovoltaic installations.

Inverters are classified into three main categories based on their nominal power and application: central inverters, string inverters, and microinverters. Currently, **string inverters lead the market, holding a 64% share**, followed by central inverters at 34%, and microinverters, which make up approximately 1% of the total. Additionally, the market for AC/DC converters — used to optimise power management at the module or string level — accounts for about 5% of the overall inverter market.

Inverters: Grid Integration

A key technological challenge for photovoltaic inverters is their effective integration into the electricity grid. Given the intermittent and decentralised nature of photovoltaic generation, advanced functionalities must be incorporated to ensure stable and secure participation as these sources come to represent a majority share of the energy mix. These functionalities focus primarily on the design and operation of inverters, which have advanced significantly in recent years. Notable developments include:

Ability to withstand **voltage dips**: A voltage dip refers to a drop in voltage of more than 10%, followed by rapid recovery. Most modern inverters are designed to handle these disturbances without compromising plant stability or disconnecting from the grid.

Synthetic inertia generation: This functionality enables inverters to contribute to the inertial behaviour of the electrical system by mimicking the dynamic response traditionally provided by rotating machines. It is crucial for maintaining stability in grids with a high penetration of renewable energy.

Grid-forming technology: Grid-forming inverters not only inject energy but can also establish and sustain an autonomous electrical grid. Technically, such an inverter can generate system voltage, provide short-circuit power, and contribute to inertia. It also allows for the disconnection of loads during low-frequency events, absorbs harmonics, interharmonics, and imbalances, and prevents

adverse interactions with other grid control elements.

GRID-FORMING TECHNOLOGY SIGNIFIES A MAJOR MOVE TOWARDS AUTONOMOUS AND STABLE POWER GRIDS.

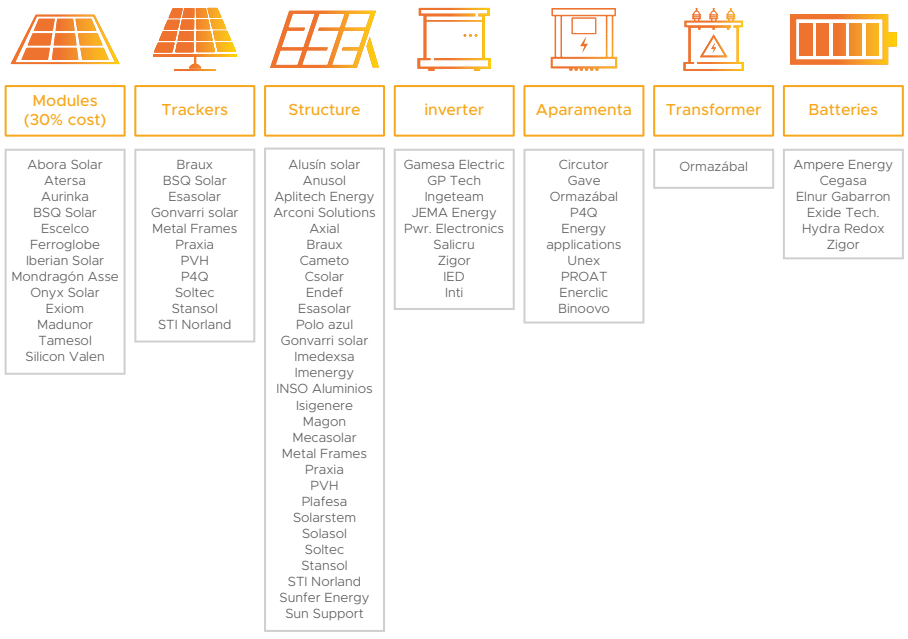
Inverters with **black-start capability**: These inverters can restart the grid following a widespread power outage and are considered a more advanced feature than grid-forming systems, as they enable autonomous recovery of supply without external support.

5.2. NATIONAL PHOTOVOLTAIC INDUSTRY:

The tariff war between China and the United States has expedited the need to **relocate strategic supply chains**, highlighting the urgency for Europe to develop its own industrial capabilities. In this context, the Net-Zero Industry Act (NZIA) presents a significant opportunity for Spain, which benefits from some of the lowest electricity prices in Europe—a crucial factor for the local manufacturing of photovoltaic components, power electronics, and storage systems.

The country boasts a strong industrial foundation in solar tracking systems, support structures, and plant design, with national companies already leading the sector on an international scale. This capability allows **up to 65% of the costs of a photovoltaic plant to be met with domestically sourced technology**, positioning Spain to become a key driver in Europe's new renewable value chain.

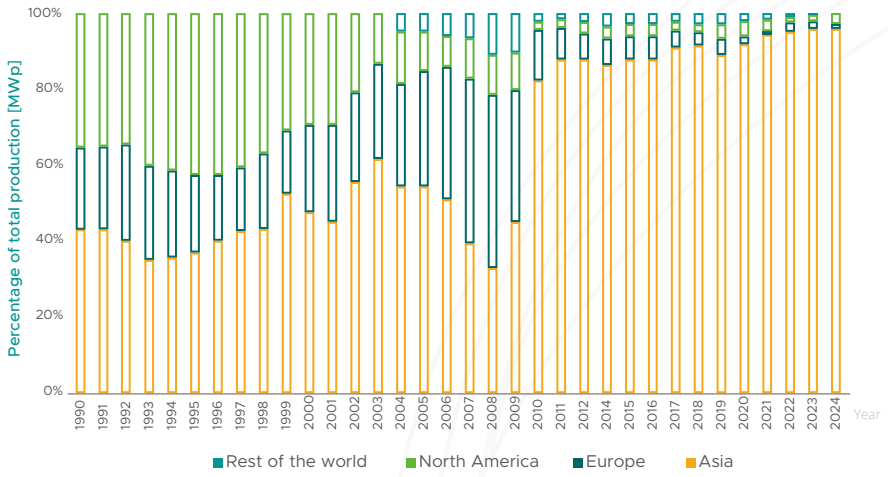
Figure 44: Spanish manufacturing companies in the photovoltaic value chain



Source: UNEF

However, despite the presence of domestic companies manufacturing components in Spain, around 30% of the total cost — primarily related to photovoltaic modules — still largely depends on Asian production.

Figure 45: PV module production by region (% total MWp produced).



Source: Photovoltaic report, Fraunhofer 2025.

Spain hosts one of the world's top ten inverter manufacturers[5] and companies that are among the leading global producers of solar tracking systems[6]. According to Wood Mackenzie's 2024 report on the tracker market, Spanish companies are among the key players in a sector that reached a record 111 GWdc shipped globally that year. Remarkably, these companies managed to achieve international prominence without initially relying on a consolidated domestic market, focusing primarily on exports to expand their operations.

According to the EU Market Outlook for Solar Power 2024-2028 report published by SolarPower Europe, by 2024 Europe will have:

- 26.1 GW for solar polysilicon production.
- 0.2 GW for ingot production.
- 0.3 GW for wafer production.
- 2 GW for cell production.
- 12.6 GW for module production.

Polysilicon production is the strongest and most self-sufficient segment of the European photovoltaic value chain, benefiting from an established industrial infrastructure and competitive supply in comparison to Asian markets. However, subsequent stages — particularly ingot cutting and wafer manufacturing — have struggled, with production levels stagnating since 2020. In this context, Spain has a robust industrial base focused on high value-added components such as inverters, solar tracking systems, and support structures,

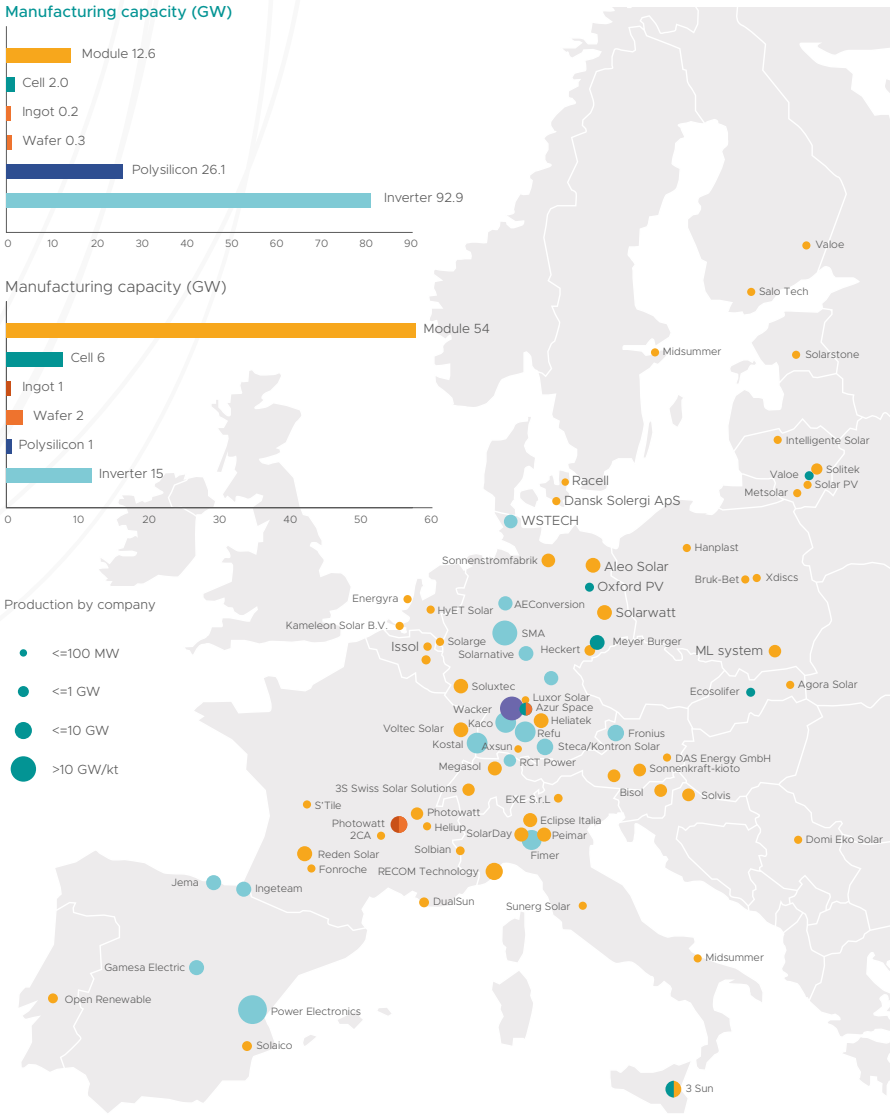
STAGNATION IN WAFER PRODUCTION IS LIMITING EUROPE'S INDUSTRIAL SELF-SUFFICIENCY.

5 https://www.cognitivemarketresearch.com/articles/which-are-the-top-manufacturing-companies-of-inverter-market?utm

6 https://www.woodmac.com/reports/power-markets-global-solar-pv-tracker-market-share-report-2025-150382314/

with leading companies on the international stage. Nevertheless, Europe's limited capacity for producing wafers and cells has led to a continued reliance on Asian imports, heightening the continent's technological and geopolitical vulnerability.

Figure 46: Industrial PV capacities in Europe



Source: EU Market Outlook for Solar Power 2024-2028. Solar Power Europe

The outlook for the European module industry, broken down by component, is as follows:

1. **Solar Silicon Production**: Wacker Chemie stands as the sole polysilicon manufacturer within the EU, boasting a capacity of 60,000 metric tonnes in Germany, which translates to over 26 GW of cell/module products. REC Solar Norway ceased operations in November 2023, resulting in a loss of 8,500 tonnes of production capacity and more than 100 jobs.

2. **Silicon Ingot and Wafer Manufacturing**: In 2023, module prices in reporting countries dropped to around USD 0.14/W, an un-

precedented low. This price drop resulted directly from the large manufacturing volumes that started in 2023, which exceeded the market's capacity to absorb them. Prices continued to decrease in 2024, falling below USD 0.10/W.

3. **Solar Cell Production**: The cell segment maintained its 2 GW capacity in 2024, with seven companies active, the same as the previous year. Meyer Burger, Europe's largest photovoltaic cell manufacturer with 1.4 GW of capacity, planned to relocate its cell production from Germany to the US after shutting down its European photovoltaic module production in March 2024. However, the company's recent restructuring put these plans on hold, so Meyer Burger's current cell production facility in Thalheim, Germany, will continue to be central to the company's solar cell supply. In a positive development, Enel 3Sun's ambitious project for a 3 GW module manufacturing plant with in-house cell capacity in Catania, Sicily, is set to ramp up production in 2025. This follows their initial 200 MW HJT cell/module line. Additionally, Dutch cell and module manufacturer MCPV is advancing with its plans after securing €4.2 million from the Dutch government to support the construction of a 4 GW solar cell plant, with the first phase expected to start production in 2026.

4. **Solar Module Manufacturing**: The module segment has seen the most changes in 2024. Module production in Europe decreased from 14.6 GW in 2023 to 12.6 GW in 2024, with several companies closing or declaring bankruptcy this year. The closure of Meyer Burger's 1.4 GW module production plant in spring 2024 had the biggest impact on this segment, as the company aimed to prevent further losses in Europe. This move was counterbalanced by an expansion of production in the US. Before deciding to close the Freiberg factory, Meyer Burger had plans to increase annual production capacity to around 3 GW in Germany by the end of 2024, which included an additional 1.4 GW of module production capacity in Freiberg. Moreover, other European module manufacturers like Solarwatt, Exasun, and Systovi were set to cease operations in 2024. Despite numerous announcements in 2023 about new module production facilities expected to open in 2024, most of these projects have been shelved, postponed, or are yet to come to fruition. As a result, only 300 MW of additional production capacity was realised in 2024, out of the more than 4 GW initially promised. Among the new capacity, Heliup, a French solar start-up specialising in lightweight modules for large roofs in the commercial and industrial segment, established a 100 MW production line in 2024 in Le Cheylas, France, to complement its existing pilot line in Le Bourget du Lac, France.

Solar **research and innovation** in Europe is supported by a robust network of specialised centres, including CENER in Spain, Fraunhofer ISE in Germany, and CEA-INES in France. Spain boasts a top-tier R&D ecosystem and industrial expertise in high-value-added components. However, several module manufacturing initiatives have ceased operations, rendering part of the infrastructure obsolete. Despite these

challenges, Spain remains strategically positioned to revitalise its photovoltaic value chain. This is thanks to the leadership of centres like CENER, strong public-private partnerships, and the increasing demand for European technology under the Net-Zero Industry Act.

Spain's significant industrial ecosystem spans sectors such as the chemical industry, metallurgy, and glass manufacturing, all of which possess the technical knowledge and production capacity necessary to support most processes in the photovoltaic supply chain.

Among the most promising projects is a joint initiative between Ferroglobe and Aurinka, focused on **producing enhanced metallurgical grade silicon** (EMGS). This effort is complemented by a photovoltaic module recycling plant in Puertollano, which can process 6,800 tonnes of discarded panels annually[7]. Aurinka also operates a module factory with a capacity of 75 MW in the Community of Madrid[8].

In the **module manufacturing** space, notable initiatives include the Escelco plant in León, with an installed capacity of 70 MW per year, and the BSQ Solar factories. Onyx Solar in Ávila is also prominent, specialising in Building-Integrated Photovoltaics (BIPV) solutions[9]. Another significant development is the forthcoming Exiom plant in Asturias, set to open in collaboration with Iberdrola, with an initial capacity of 500 MW and a total capacity of 2.7 GW. Sunwafe has also unveiled ambitious plans to manufacture wafers and cells in Spain, targeting a capacity of 20 GW by 2030, supported by European funding[10].

SAFEGUARDING THE INDUSTRIAL BASE IS CRUCIAL FOR COMPLETING THE PHOTOVOLTAIC VALUE CHAIN.

Finally, Spanish **engineering, services, and consulting** companies related to solar energy play a strategic role in the sector's global expansion. They transfer expertise to international markets and help solidify Spain's position as a competitive industrial hub in the photovoltaic value chain.

In this context, Spain is well poised to become a major photovoltaic industrial hub. To reach this goal, it is crucial to safeguard the existing industrial base, ensure a stable domestic market, and improve access to tailored financing for local manufacturers.

Fully integrating the photovoltaic value chain requires a coordinated strategy. This strategy should position the industry as a central pillar of technological and energy development in Europe, similar to the model used for hydrogen. Boosting the European solar industry should go hand in hand with policies that replicate the catalytic effect feed-in tariffs once had on the growth of renewable energy.

7 https://cadenaser.com/castillalamancha/2025/06/17/ferroglobe-instalara-una-planta-de-tratamiento-de-plantas-fotovoltaicas-en-puertollano-ser-ciudad-real/
8 https://iea-pvps.org/wp-content/uploads/2024/12/IEA-PVPS-2023-National-Survey-Report-Spain.pdf
9 Idem
10 https://www.pv-tech.org/spain-launches-e100-million-renewables-recycling-aid-programme/

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5.3. PHOTOVOLTAIC INNOVATION: AGRIVOLTAICS, FLOATING AND BIPV

Agrivoltaics

Agrovoltaics is an innovative model that **integrates agricultural or livestock production with photovoltaic energy generation within the same space, creating synergies between the two**. The design is tailored to the specific type of crop, livestock, and local climate by using intelligent light management beneath the solar panels. This approach is particularly beneficial in arid or semi-arid regions, as it enhances water use efficiency and shields crops from excessive sunlight. In recent years, this technology has garnered increasing interest from companies, institutions, and research centres.

Agrivoltaics offers a production model that combines environmental, social, agronomic, and economic benefits. From an **environmental perspective**, agrivoltaics reduces water evaporation, protects soil from erosion, and serves as a carbon sink. In **agronomic terms**, controlled shading alleviates the impacts of extreme heat, excessive radiation, hail, and frost, stabilises yields, manages ripening processes, and enhances crop quality. On a **social level**, it can help maintain populations in rural areas, bolster resilience to climate change, and add value to the region. **Economically**, it diversifies income for farmers and livestock breeders, increases land value, and improves profitability by allowing the simultaneous production of food and energy.

Figure 47: Agrivoltaic installation in the Daramezas Estate of Viñedos del Río Tajo.

Source: Bodega Las Copas, Viñedos de Río Tajo

Germany, France, and Italy have led the way in agrovoltaic development in Europe by establishing specific technical standards and support programmes. Germany's DIN SPEC 91434 (for crops) and DIN SPEC 91492 (for livestock) ensure the priority of agricultural use. In France, the APER Law (2023) and Decree 2024-318 require

that agricultural production remains significant (≥90% of reference yield) and restrict land use. Italy supports advanced systems via the PNRR, aiming to install 1.04 GW of innovative agrovoltaic capacity through differentiated auction mechanisms.

Spain, with significant solar and agricultural potential, is at an early stage, characterised by pilot projects in woody and horticultural crops. Initiatives such as WineSolar (Toledo), GO Agrivoltaica AND (Córdoba), and the olivevoltaic system in Jaén illustrate the technical and economic feasibility of these models. However, large-scale deployment is still hampered by the absence of specific regulations, a lack of standardised business models, and the need to tailor designs to the agricultural calendars and requirements of local farming.

AGROVOLTAICS HAS THE POTENTIAL TO INCREASE TOTAL LAND PRODUCTIVITY BY AS MUCH AS 70%.

The **main barriers** in Spain are regulatory, economic, and technical. On the regulatory front, there is still no unified definition of agrovoltaics or a framework to ensure compatibility with the Common Agricultural Policy (CAP). Technically, there is a shortage of standardised tools for agronomic and microclimatic modelling, alongside modules and structures optimised for different crops. Economically, high initial costs and the absence of mechanisms to evaluate agronomic benefits, such as water savings or improved crop quality, hinder competitiveness with traditional photovoltaic projects.

Experience from Europe and national pilot projects highlights the importance of thorough agronomic planning, active involvement of farmers, and designs that cater to the specific needs of each farm. It is essential to monitor both agricultural and energy data together to evaluate profitability and sustainability. Furthermore, the restrictions specified in Environmental Impact Statements (EIS), like limits on the use of agrochemicals, bear a resemblance to organic farming practices in several respects.

Figure 48: Conceptualisation of Bioagrivoltaics.

Source: UNEF

In this context, the concept of BIOagrovoltaics has emerged, combining organic farming with photovoltaic generation to promote a resilient, low-emission rural model with significant social benefits.

Floating solar

Floating photovoltaic solar technology involves **placing solar panels on platforms that float on bodies of water**, such as reservoirs, lakes, or irrigation ponds. This innovation has become a promising

alternative for the energy transition, particularly in areas where land is scarce or expensive. Besides generating clean electricity, it reduces evaporation and algae growth in water bodies, enhances water quality in eutrophicated reservoirs, and boosts module efficiency by 5-15% due to the natural cooling effect of the water compared to land-based systems.

The main applications of floating solar technology include:

- Reservoirs and hydroelectric power stations, making use of existing infrastructure and networks.
- Irrigation ponds, which are a priority in the agricultural market.
- Water treatment tanks, desalination plants, and irrigation channels.
- Aquaculture, as well as quarries and flooded mines.
- Hybrid projects with offshore wind or green hydrogen.

On the international stage, Asia leads the market with major projects in China, South Korea, India, and Thailand. Meanwhile, Europe is advancing with notable installations like Alqueva in Portugal and Bomhofsplas in the Netherlands. According to IRENA, global installed capacity reached approximately 3 GW in 2023, with capacity doubling approximately every two years, and it is anticipated to surpass 6 GW by 2030.

ROYAL DECREE 662/2024 SETS OUT THE LEGAL FRAMEWORK FOR FLOATING SOLAR POWER IN SPAIN IN 2024.

In Spain, which boasts over 1,200 reservoirs and high solar radiation, floating solar parks are in the early stages of development. However, they benefit from a clear regulatory framework established by Royal Decree 662/2024. This decree limits the occupation of the water surface to between 5% and 15%, based on the reservoir's trophic status, and mandates concessions with a maximum duration of 25 years. Examples like the Sierra Brava reservoir plant in Cáceres and the irrigation facility in Huelva show that this technology is both viable and promising.

The main technological challenges concern the durability of flotation systems, anchor and mooring designs, corrosion, salt deposition, and the development of integrated electrical systems to ensure safety and efficiency in aquatic environments.

Building Integrated Photovoltaics: BIPV

Building Integrated Photovoltaics (BIPV) is becoming a **crucial component in achieving nearly zero-energy building standards**. This technology replaces traditional building envelope elements — like roofs, facades, and windows — with architectural components that include photovoltaic cells. These components serve a dual purpose: they function as construction materials while generating clean energy for self-consumption.

The main challenge is to develop solutions that effectively combine efficiency, aesthetics, and regulatory compliance. Innovation is therefore directed at enhancing the performance of BIPV modules, diversifying designs and textures, and lowering manufacturing and installation costs to speed up their adoption in sustainable construction.

5.4. FOTOPLAT

Fotoplat serves as Spain's platform for photovoltaic technology. It is an initiative by the Ministry of Science aimed at:

- Facilitating **networking** among photovoltaic **researchers**
- Helping to connect these **researchers** with **companies** that can use their technology via **networking**
- **Raising awareness** of photovoltaics within Spanish society
- Preparing advisory **documents** for the Ministry of Science **on which photovoltaic technologies to support** in research and the methods to do so

DURING 2024, FOTOPLAT ADDED 11 NEW ENTITIES, BRINGING ITS TOTAL MEMBERSHIP TO 250 ORGANISATIONS BY THE YEAR'S END.

Currently, UNEF manages this project. Fotoplat operates as an association of Spanish companies and entities with an interest in photovoltaics, ranging from universities and research centres to individuals and large corporations.

In 2024, the platform was restructured, with the main emphasis now on thematic quarters.

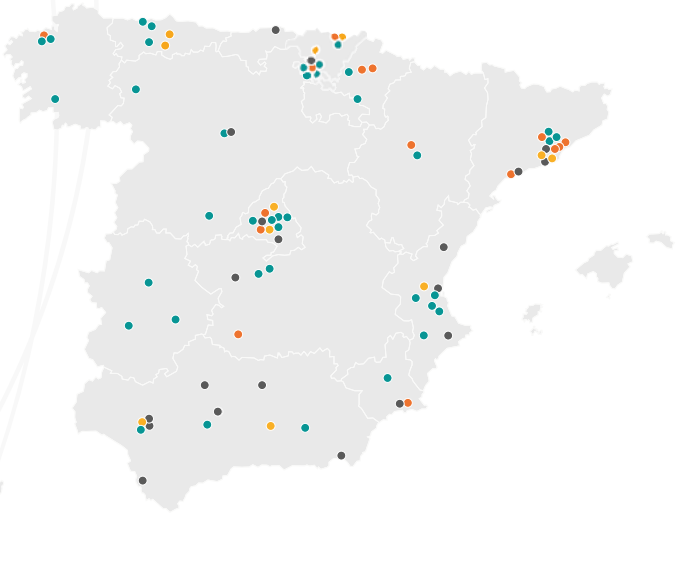
These quarters consist of a series of webinars focused on different topics

Thematic quarters:

1. Agrivoltaics
2. Recycling of photovoltaic panels
3. Grid-Forming

Another key initiative by Fotoplat is the capacity map. It outlines Spanish research centres, manufacturers, and technologists involved in photovoltaics

Figure 49. Capacity map of the Spanish photovoltaic industrial sector.



Source: UNEF and FOTOPLAT

Manufacturers:

- Alusín Solar (Structures)
- Ampere Energy (Batteries)
- Atersa (Panels)
- Braux (Structures, Trackers)
- BSQ Solar (Modules)
- Cegasa (Batteries)
- CSolar (Structures)
- Esasolar (Structures, Trackers)
- Escelco (Panels)
- Exide Technologies (Batteries)
- Ferrosolar (Silicon Purification)
- Gave (Protections)
- Gonvarri Solar Steel (Trackers, Structures)
- GP Tech (inverter)
- Hydra Redox (Batteries)
- Imedexsa (Structures)
- Ingeteam (inverter)
- INSO (Structures)
- Isigenere (Floating PV)
- JEMA Energy (inverter)
- Magon (Structures)
- Mondragon (Module assembly)
- Onyx Solar (Panels)
- Ormazabal (Electrical equipment)
- Power electronics (inverter)
- Praxia (Structures, Trackers)
- PVH (Trackers and Structures)
- Sener (Followers)
- Solarstem (Structures)
- Soltec (Trackers, Structures)
- Stansol (Structures, Trackers and Floating PV)
- STI Norland (Trackers, Structures)
- Sunfer Energy (Structures)
- Sun Support (Structures)
- Trina Solar (Trackers and Structures)
- Zigor (inverter, Batteries)
- Izpitek Solar (Electrical equipment)
- HD Solar Spain (Electrical equipment)
- IDAIN Professionals (Electrical equipment)

Technology companies:

- Acciona
- Binoovo Solar
- Enertis
- Exiom group
- Green Power Monitor
- Isotrol
- Leadernet
- Phoenix Contact
- Tamesol
- Tecnalia
- Teknia group
- Weidmuller
- Engineering Simulation Consulting
- Whitewall energy
- Spanish Energy Storage Association
- Suntropy
- IECO

Research centres:

- CENER
- CETENMA
- CIC Energigune

- CIEMAT
- CIRCE
- Eurecat C. Tecnológico Cataluña
- Funditec
- ICMAB-CISC
- IK4 Tekniker
- ICIQ Inst. Catalan Inv. Química
- IMDEA Energía
- ITER Instituto Tecnológico y de Energías Renovables
- Instituto Tecnológico de Galicia
- IREC Inst. Inv. Energía de Cataluña
- Instituto Tecnológico de Canarias

Universities and institutes:

- EPSU Mondragón
- Instituto de Energía Solar UPM
- Instituto de Materiales Avanzados UJI
- ICFO Instituto de Ciencias Fotónicas
- ISFOC
- Nanophotonics Tech Center, UPV
- Univ. Pablo de Olavide
- Univ. Carlos III de Madrid
- Univ. de Almería
- Univ. de Cantabria
- Univ. de Castilla-La Mancha
- Univ. de Córdoba
- Univ. de Jaén
- Univ. Politécnica de Cartagena
- Univ. Politécnica de Cataluña
- Univ. de Sevilla
- Univ. de Cádiz
- Univ. de Valladolid
- Univ. de Miguel Hernández
- Univ. de Rovira i Virgili

Fotoplat public reports include the Market Study and Internationalisation Plan, the State of the Industry and Photovoltaic Technology, the Photovoltaic Strategy and Socio-Environmental Aspects.

FOTOPLAT OFFERS ITS MEMBER ORGANISATIONS A VARIETY OF TOOLS DESIGNED TO HIGHLIGHT SPAIN'S EXPERTISE, INDUSTRIAL POTENTIAL, AND TECHNOLOGICAL KNOWLEDGE IN THE PHOTOVOLTAIC SECTOR.

In 2024, as part of its mission to facilitate knowledge exchange among various players in the photovoltaic ecosystem, FOTOPLAT continued to actively engage in key industry events such as the 10th Solar Forum and GENERA 2024. On these occasions, the platform organised sessions that focused on sharing the latest trends and technological advancements in photovoltaics.

FOTOPLAT has also maintained and strengthened its collaboration with other Spanish Technology Platforms that share the objectives of the energy transition. Noteworthy initiatives include its active role in the Coordination Committee of **Energy Technology** Platforms (CCPTE) and the GICI Group of the **FUTURED platform**. Within this framework, they organised a roundtable discussion during the CCPTE's annual meeting, featuring a high-level representative from FOTOPLAT.

At the European level, the platform remains actively involved in strategic networks such as the European Technology Platform for Photovoltaics (ETIP PV) and the **EERA-PV Joint Programme**. It also formalised a collaboration agreement with EU-PVSEC in 2023. On the international stage, FOTOPLAT collaborates with the International Energy Agency (IEA) within the **PVPS programme**, where it contributes to strategic analysis and the promotion of BIPV. Additionally, it is involved in the **SHC programme** (Solar Heating and Cooling Programme).

5.5. OUTLOOK

Photovoltaic energy has become a key player in the global energy transition. By 2030, it is expected that renewable energy sources will contribute approximately 80% of new electricity capacity, with photovoltaics leading the way. **The global production capacity for modules is rising and could surpass 100 GW annually by the end of this decade**, although current deployment uses only part of this potential. This growth opportunity positions photovoltaics as crucial for achieving decarbonisation goals.

Since 2020, global investment in renewables has surged by 79%, with more than €1.8 billion a day directed towards photovoltaics[11]. This upward trend highlights its technological maturity and significant role in reindustrialisation and creating green jobs. In this context, Spain enjoys unique competitive advantages: some of the lowest electricity prices in Europe, a well-established value chain in high-value components such as power electronics, structures, and tracking systems, and a leading R&D ecosystem. Additionally, projects are underway to increase wafer and cell production capacity to 20 GW by 2030, supported by European funds.

However, rapid growth also brings technical challenges, particularly in grid integration and managing surpluses. **Developing a national battery industry is essential**, both for stand-alone systems and hybrid installations with photovoltaics, to ensure the stability and flexibility of the electricity system. The global supply chain remains heavily concentrated in Asia, underscoring the need for a Spanish techno-industrial strategy that protects domestic production, supports manufacturer financing, and ensures a national technological reserve to maintain energy sovereignty.

The expansion of photovoltaics is driving structural change in the energy system, reducing reliance on fossil fuels and supporting the goals of the National Integrated Energy and Climate Plan (PNIEC). Projections from the International Energy Agency (IEA) confirm that speeding up the transition with clean technologies like solar is essential for limiting global warming to 1.5 °C. Aligning public policies, private investment, and international cooperation is crucial, as is establishing a national regulatory framework to support both the photovoltaic industry and storage solutions.

Photovoltaics is not only a vital tool for decarbonisation but also offers Spain a **historic opportunity to become a European industrial hub**. Achieving this will require strengthening innovation, regulatory stability, and support mechanisms for manufacturing and storage.

11 IEA, World Energy Investment 2025.


Solar Steel
Gonvarri Industries
TracSmarT+1p
Discover our new 1P tracker
Designed for the future
Built for today

6 | SPANISH PHOTOVOLTAIC UNION (UNEF)

6.1. WHAT IS UNEF?

Founded in 2012, the Spanish Photovoltaic Union (UNEF) has now existed for 12 years and has become the leading photovoltaic association in Spain and one of most prominent in the renewable energy sector.

In 2024, the association gave a voice to more than 800 companies across the entire value chain.

UNEF is organised into **six sections**: Storage, Energy Communities, Distributors, Manufacturers, Installers and Engineering, Producers and a Mixed section. This structure forms a democratic forum that advocates for regulatory stability, sustainable development and the internationalisation of the photovoltaic sector.

The association also holds the presidency and co-secretariat of FOTOPLAT, the Spanish Photovoltaic Technology Platform. Initiated in March 2011 by the Ministry of Economy, FOTOPLAT brings together universities, research centres and leading companies in photovoltaic R&D&i in Spain.

UNEF is also a member of the European photovoltaic industry association, SolarPower Europe, where it chairs the National Associations Committee, and a founding member of the Global Solar Council, a leading international association. As a meeting forum

UNEF has an open institutional structure designed to include all sector participants, regardless of their activity, size, or area of operation. In 2024, the assembly approved changes to its statutes to welcome new participants, increase the number of board members, and establish a Management Committee.

The **General Assembly** serves as the association's governing body. During these meetings, they approve the annual budget, the action plan and, if necessary, elect representatives for the Board of Directors.

IN 2024, UNEF UPDATED ITS STATUTES, EXPANDED ITS BOARD, AND ESTABLISHED THE MANAGEMENT COMMITTEE.

The **Board of Directors**, elected every two years during the General Assembly, represents the interests of UNEF's various sections. It also includes the individuals responsible for General Management, the General Secretariat and the representative of the Territorial Delegations.

UNEF has delegations in fifteen autonomous communities that engage directly with regional governments and regularly bring together local companies. In Catalonia, UNEF operates under the UNEFCAT brand and established the Territorial Council of Catalonia in 2021 as an advisory body composed of companies based in the region.

Figure 50: UNEFCAT in Barcelona

Source: UNEF

Sections by sector activity

UNEF is organised into six distinct sections based on the activities of its member companies:

Storage Section: this is for companies involved in the manufacturing, distribution or sale of storage systems for photovoltaic projects.

Energy Communities Section: companies working with renewable energy generation, energy efficiency services, supply, consumption, aggregation and storage within an energy community fall under this category.

Distributors Section: this section includes companies that distribute components for photovoltaic systems.

Manufacturers Section: designed for companies that produce solar-grade silicon, wafers, cells, modules, inverters, module support structures and other specific components for photovoltaic systems.

Installers and Engineering Section: this is for member companies involved in system assembly, project engineering, system maintenance and the administrative processing of photovoltaic projects.

Producers Section: companies primarily focused on electricity production belong to this category.

Mixed Section: this section encompasses various activities, such as project financing, the production of auxiliary components for photovoltaic systems, consultancy or professional services, market representation, research centres, public entities, testing and certification laboratories, training centres, technological innovations, etc.

The UNEF team comprises professionals from various fields **who collaborate** to manage all the association's activities effectively. The technical office, led by a general directorate, is organised into **11 directorates**. They are responsible for crafting and implementing the strategic focus of the sectoral association. They include the technical, self-consumption, energy communities, storage & green hydrogen, associates and marketing, events, institutional & international, communication, regulation & financing, social acceptance, and studies and environment directorates. Currently, the UNEF team consists of 19 members.

Figure 51: UNEF Team

Source: UNEF

6.2. OBJECTIVES OF UNEF

UNEF aims to strengthen Spain's leadership in photovoltaic energy by serving as the voice of the sector to public administrations and both national and international organisations. It is committed to advancing a decarbonised and competitive energy model rooted in solar power, encouraging self-consumption and the integration of clean energy as **vital tools in combating climate change and safeguarding biodiversity**.

The association advocates for stable regulation and legal certainty to provide confidence for investors and ensure the sector's orderly growth. In 2024, UNEF enhanced this strategy by engaging in ongoing dialogue with the government, autonomous communities, the European Commission, local councils, political parties, institutions like the IDAE, OMIE and CNMC, as well as with social stakeholders and representatives of the energy sector.

Services for members

UNEF keeps its member companies well-informed through regular sector alerts, a daily newsletter covering key press news, a weekly update on the association's most significant activities, a monthly newsletter highlighting key sector indicators, and a quarterly report on the state of the electricity market.

UNEF ADDRESSED OVER 590 TECHNICAL AND LEGAL ENQUIRIES THAT YEAR.

In 2024, **over 498 communications** were sent out to an internal list of more than 3,300 people and an external list of about 4,000 contacts. The average open rate for these communications was nearly 50%.

In addition, UNEF provides its members with technical and legal advice on topics such as grants and subsidies, regulations, access and connection, taxation, and environmental issues related to photovoltaic energy. This service is highly valued by members, who **made over 590 enquiries** in 2024.

Institutional action

UNEF engages in ongoing discussions with key energy regulators at both the **national and European levels**, ensuring that policy decisions are grounded in reliable data and reflect the conditions of the photovoltaic sector. The association has an extensive network of institutional, political, and social contacts that bolster its strategic objectives.

In 2024, UNEF strengthened its position as a key representative for the entire value chain of the sector in dealings with the M**inistry for Ecological Transition and Demographic Challenge (MITERD)**, including the Secretaries of State for Energy and the Environment. Additionally, UNEF established a direct communication channel with the **Ministry of Economy, Trade and Business (MINECO)**. It joined the Working Group on Capital Goods and Electrical Equipment, coordinated by the Directorate-General for International Trade and Investment and the Directorate-General for Industrial Strategy. This collaboration addresses issues such as industrial competitiveness and the new US tariff policy.

We have strengthened links with spokespersons from all parliamentary groups in **Congress and the Senate**, maintaining strate-

gic dialogue with **REE (REDEIA)** before, during, and after the energy crisis on 28 April. Many of UNEF's proposals were included in **Royal Decree-Law 7/2025 of 24 June**, which introduced urgent measures to bolster the electricity system.

THE ORGANISATION ENHANCED ITS INSTITUTIONAL INFLUENCE THROUGH MORE THAN 80 MEETINGS AND PIVOTAL REGULATORY PROPOSALS.

Regionally, UNEF has advocated for measures to streamline administrative processes and integrate storage with photovoltaics. A joint letter with the **Network of Regional Energy Directors** was sent to MITERD, and we engaged in dialogue with initially reluctant governments in regions like **La Rioja** and **Murcia**, achieving institutional rapprochement. We also held UNEF Sustainability and Agrovoltaics Conferences in **Valencia, Extremadura, Andalusia, and Murcia**, fostering dialogue between the regional ministries of Energy and Agriculture. Additionally, we have strengthened relationships with environmental organisations and regional associations to support a more sustainable and inclusive energy transition.

Figure 52: UNEF-FEMP Meeting

Source: Spanish Federation of Municipalities and Provinces

UNEF has actively worked with local, regional, and national governments through meetings, proposals, and technical advice. It collaborates with representatives from the renewable energy sector and civil society, including political parties, environmental groups, and agricultural organisations. UNEF also partners with technological development and R&D&I organisations, such as CDTI and CIEMAT, as well as universities, research centres, and innovative companies, maintaining the FOTOPLAT Secretariat as a key platform. Furthermore, UNEF acts as a Collaborating Agent with ICEX and participates in the Solar Sector Plan.

Comments and Regulatory Proposals

In 2024, UNEF significantly increased its regulatory activities compared to 2023, submitting **46 public consultations and 6 amendments**. This increase not only highlights the heightened regulatory environment but also demonstrates **the effectiveness of the**

association's advocacy efforts. Many of our contributions have been incorporated into draft regulations, which has lessened the need for further amendments.

In the first half of 2025, UNEF submitted 4 amendments and 34 proposals, **maintaining its proactive approach**. The positions of UNEF are developed in the Working Groups and approved by the Board of Directors, and they are making a tangible impact on the development of regulations for both ground-mounted plants and self-consumption. Furthermore, the association is strengthening its role as a key representative by crafting proposals and publishing technical reports that aid in crafting a stable and predictable regulatory framework.

Promotion of RDL 7/2025

In 2024 and 2025, UNEF spearheaded a vigorous campaign to secure the approval of Royal Decree-Law 7/2025, known as the anti-blackout RDL. This regulation is key for the industrialisation, energy independence, and competitiveness of the sector. Although the text was eventually repealed in Parliament due to political reasons unrelated to its technical merits, UNEF successfully garnered widespread support from parliamentary groups, business associations, energy entities, environmental organisations, and industrial stakeholders, forming an unprecedented sector-wide consensus.

UNEF SPEARHEADED A GROUNDBREAKING CAMPAIGN IN SUPPORT OF RDL 7/2025, SECURING WIDESPREAD TECHNICAL AND INDUSTRY CONSENSUS.

Coordinated by UNEF, the sector's collective efforts involved meetings with all political parties, sending letters to regional leaders, securing backing from national and international organisations, and crafting specialised technical documents to highlight the regulation's strategic significance.

This mobilisation reached a vital, albeit partial, goal: preventing the expiration of the fifth milestone, which had a deadline of 25 June. This allowed developers who submitted their applications on time the opportunity to alter their connection semester.

Support for internationalisation

In 2024, UNEF bolstered its international strategy to attract foreign investment and aid the expansion of its member companies. Working with **ICEX Invest in Spain**, UNEF coordinated meetings among international companies, financial institutions, and regional authorities. It also developed a **"Welcome Package"** to ease the entry of new investors.

UNEF CHAIRS THE SOLARPOWER EUROPE NATIONAL ASSOCIATIONS COMMITTEE.

After its initial participation in 2023, UNEF returned to Intersolar 2024 with a collaborative stand. This provided member companies access to Europe’s leading solar industry trade fair, which connects

the solar, photovoltaic, and thermal technology markets. Through ICEX, UNEF also facilitated participation in Intersolar 2025 and organised a Spanish-Portuguese Conference to enhance cooperation between the two countries.

Internationally, UNEF has worked closely with the **International Energy Agency (IEA)** on the PVPS Task 1 programme, contributing to strategic reports like the Trends Report, Annual Report, National Survey Report, and Snapshot. It also collaborates with **IRENA** as a member of the Coalition for Action and engages with the **Global Solar Council** in the Finance Workstream.

UNEF CONTRIBUTES TO KEY IEA PVPS REPORTS, BOLSTERING ITS INTERNATIONAL LEADERSHIP.

Within Europe, UNEF is actively involved in **SolarPower Europe (SPE)** and takes part in workstreams such as the Affordable Energy Action Plan, Clean Industrial Deal, Local Investment Signals, and Market and Investment, among others.

UNEF has also started collaborations with strategic sectors, such as data centre associations, to boost electricity demand. Additionally, it has signed agreements with universities and industry organisations to support the training of young professionals and bring them into the photovoltaic value chain.

6.3. SUMMARY OF UNEF ACTIVITIES

Agrivoltaics Conference

The agrivoltaics conference aims to raise awareness of the model that combines solar energy with agriculture, promoting efficient land use and enhanced sustainability. It also strives to establish a collaborative ecosystem among photovoltaic companies, universities, research centres, the agricultural sector, and public institutions.

On **22 January 2025**, we organised a conference in Badajoz featuring experts and authorities from Spain and Portugal. Notable speakers included Nelson Lage, Chairman of the Board of Directors of the Portuguese Energy Agency, Miguel Rodrigo, Director General of the IDAE, and representatives from the Government of Extremadura.

The second event took place on **10 April 2025 in Seville** and attracted over 200 participants. Andalusia was chosen as the venue due to its leadership in renewable energy and sustainable agriculture, making it an ideal location. This time, representatives from the IDAE, the Andalusian Regional Government, and the Ministry of Agriculture, Fisheries and Food took part.

Figure 53. Agrivoltaics conference in Andalusia. Innovation for a sustainable future

Source: UNEF

Sustainability and Photovoltaic Plants Conferences

The aim of these conferences is to **highlight best practices in the Spanish photovoltaic sector**, with a focus on biodiversity, re-wilding, and creating opportunities for the region's economic and social development.

Several such events took place last year. The first conference was held in **Valencia on 9 July 2024**, featuring a presentation on the role of photovoltaic plants in biodiversity conservation, as well as showcasing the UNEF Seal of Excellence in Sustainability. The involvement of representatives from the Valencian Regional Government enabled discussions on the specific challenges and opportunities faced by this autonomous community.

The second conference, attended by over 200 people, took place on **28 January 2025 at the Congress of Deputies** in Madrid. This event introduced the new Seal of Excellence in Storage, promoted by UNEF. Miguel Ángel Hernández, project coordinator at EMAT, highlighted the key points from the 2024 Sustainability and Photovoltaic Plants Report.

Figure 54. 3Rd Sustainability and Photovoltaic Plants Conference

Source: UNEF

On **19 June 2025**, the third sustainability conference took place in Catalonia, featuring the theme 'Lessons learned from the 33 GW in operation in Spain'. This event focused on exploring experiences and opportunities within the region.

Also on **19 June 2025**, **another sustainability conference** was held with the same theme. This event aimed to analyse opportunities and various examples from Catalonia specifically.

III Storage and Renewable Hydrogen Summit

The third Storage and Renewable Hydrogen Summit was held on **11 and 12 February 2025**, under the theme "The capacity mechanism as a driver of profitability for storage and renewable hydrogen". The event brought together over **500 attendees**. Over the two days, participants tackled key issues such as technology, the value chain, regulation, business models, industrial decarbonisation, financing, digitalisation, and industrial safety. The event featured important figures, including **Joan Groizard**, the Secretary of State for Energy at the Ministry for the Ecological Transition and Demographic Challenge, as well as representatives from public bodies in the Community of Madrid, the Andalusian Regional Government, and the Community of Valencia.

Figure 55. 3rd Storage and Hydrogen Summit

Source: UNEF

FOTOPLAT Assembly

The FOTOPLAT Annual Assembly took place on **3 April 2025**, themed "Innovation and entrepreneurship in synergy: connecting start-ups with photovoltaic R&D&I". The meeting aimed to boost collaboration between companies and institutions to keep Spain and its business landscape at the forefront of research, develop-

ment, and innovation in photovoltaic systems. It also sought to promote common strategies and foster synergies among various sector players.

V Self-consumption Summit

The 5th Self-Consumption Summit, held on **24 April 2025, was attended by over 300 participants**. The event examined the sector's progress since the approval of Royal Decree 244/2019 and discussed new initiatives to promote this clean form of energy consumption. It also explored the growth of collective self-consumption and the inclusion of new elements such as storage and energy communities, which are key to increasing installed capacity.

The conference featured important presentations, including the Manual of Good Practices in Fire Safety for Sustainable Self-Consumption Photovoltaic Installations (UNEF), the new Self-Consumption Platform (Red Eléctrica), and the EBAFLEX study from the Polytechnic University of Valencia. Notable attendees included **Miguel Rodrigo**, Director General of the IDAE, along with representatives from the CNMC, Red Eléctrica, the Regional Governments of Extremadura and Andalusia, and the Ministry for Ecological Transition and Demographic Challenge.

Figure 56. V Self-consumption Summit

Source: UNEF

Solar Forum

The eleventh edition of the Solar Forum took place on **9 and 10 October 2024**, marking the most significant event of the year for photovoltaic energy in Spain. The forum, themed "Photovoltaic energy, the driving force behind industrialisation", attracted

over 1,100 sector representatives. It brought together key figures such as **Sara Aagesen**, Secretary of State for Energy; **Eva María Blanco**, Deputy Director of Environmental Assessment; and **Víctor Marcos**, Director General of Energy Planning and Coordination, all from the Ministry for the Ecological Transition and Demographic Challenge. Other notable participants included **Alipio García**, Director General of Energy Transition for Castilla-La Mancha; **Marcelo Álvarez**, President of the Solar Committee of the Argentine Chamber of Renewable Energy; **Rebeca Torró**, Secretary of State for Industry; and **Manuel Argüelles**, Director General of Energy and Mines for the Valencian Regional Government, among others.

Figure 57: XI Solar Forum

Source: UNEF

Over the course of two days, leading companies, public institutions, and civil society representatives came together to discuss the challenges and opportunities in accelerating the energy transition, as well as contributing to the country's reindustrialisation and economic recovery.

Training courses

- **Electricity Market Course.** This online course is designed for producers, installers, operators, and other professionals in the photovoltaic sector. Participation has steadily increased each year, owing to its practical approach to understanding how Spain's wholesale electricity market operates, covering areas such as the daily and intraday markets, settlement calculations, billing, and adjustment services. In 2024, the course added content on analysing projects awarded through auctions, market projects, and PPA contracts. By 2025, it further expanded to cover new developments related to the integration of storage and energy communities into the market.

- **Project Finance course**. This online course, conducted on 18 and 19 September 2024, aimed to explain the essential financial concepts involved in funding photovoltaic projects and to equip participants with the key tools needed to evaluate them effectively.

- **Course on promoting facilities: generation and storage** Held in person on 3 December 2024, this course covered the practical aspects of promoting photovoltaic plants. It included discussions on the regulatory framework, site selection, access and connection procedures, and the integration of storage systems, among other relevant topics.

Webinars

BETWEEN 2024 AND 2025, UNEF HELD VARIOUS ONLINE SESSIONS, ATTRACTING OVER 1,800 PARTICIPANTS IN TOTAL.

- **Optimising photovoltaic plant performance** (3 October 2024), focusing on robotic and automated solutions for vegetation management and panel cleaning.
- **Module quality controls** (10 December 2024), discussing the prevention and management of contractual breaches.
- **Social licence and access capacity tenders** (23 January 2025), which attracted 600 participants and addressed the issue of social acceptance in renewable projects.
- **Preventing social rejection in photovoltaic and storage projects** (21 and 28 May 2025), attended by over 400 participants and conducted by Mediación Verde.
- **Linked operations in renewable projects** (3 June 2025), covering contractual matters and responses to tax inspections, in collaboration with Schlaich Dauss and Crowe.

6.4. COMMITMENT TO SUSTAINABILITY

Seal of excellence in sustainability

At UNEF, we work to promote a sustainable energy transition by ensuring that the development of new renewable facilities brings direct benefits to the region and creates shared value with local communities. In 2019, we published our Sustainability Recommendations, a document outlining measures to **enhance the environmental and social integration of photovoltaic plants**. We presented this document to the Vice-President and Minister for Ecological Transition, Teresa Ribera, and shared it with the regional administrations responsible for sustainability.

Figure 58: Seal of excellence in sustainability

Source: UNEF

UNEF has developed the **Seal of Excellence in Sustainability**, a unique certification system that ensures photovoltaic projects meet high standards in four key areas: socio-economic impact, environmental integration and biodiversity protection, governance, and circular economy. Independent certifiers, currently Applus+ and SGS, conduct the audits. Sixty-one plants have been awarded this seal, representing a total capacity of 4,725 MW.

Seal of Excellence in Storage

IN 2024, UNEF INTRODUCED THE SEAL OF EXCELLENCE IN STORAGE, SETTING A STANDARD FOR SUSTAINABILITY AND SAFETY.

In 2024, UNEF introduced the **Seal of Excellence in Storage,** a groundbreaking certification designed to ensure that both stand-alone and hybrid storage facilities adhere to the highest standards of sustainability, safety, and quality. The seal sets rigorous criteria in five critical areas: socio-economic impact, environmental integration and biodiversity, industrial safety, governance, and circular economy. This scheme is audited by independent entities and aims to foster projects that create shared value with local communities, reduce environmental impact, and enhance transparency and dialogue with local stakeholders.

Figure 59: Seal of Excellence in Storage

Source: UNEF

The new seal provides a unique framework for certifying storage systems, whether linked to photovoltaic plants or operating independently. Through this initiative, UNEF is strengthening its **commitment to a just and sustainable energy transition**. The focus is on promoting storage solutions that align with decarbonisation goals, foster technological innovation, and create economic opportunities within local communities.

6.5. RESEARCH

THE ORGANISATION FURTHER SOLIDIFIED ITS ROLE AS A KNOWLEDGE LEADER IN THE SECTOR BY PRODUCING OVER 30 STUDIES AND ANALYSES.

In 2024, UNEF's research department stepped up its efforts to generate knowledge, releasing a range of reports, studies**, and analyses. These covered electricity** market trends, developments in self-consumption, behind-the-meter storage, project approvals, biodiversity in solar plants, and regulatory suggestions. UNEF contributed to international organisations such as the **International Energy Agency, IRENA, REN21, and SolarPower Europe**, strengthening its position as a technical and regulatory leader in the sector.

Sustainability studies

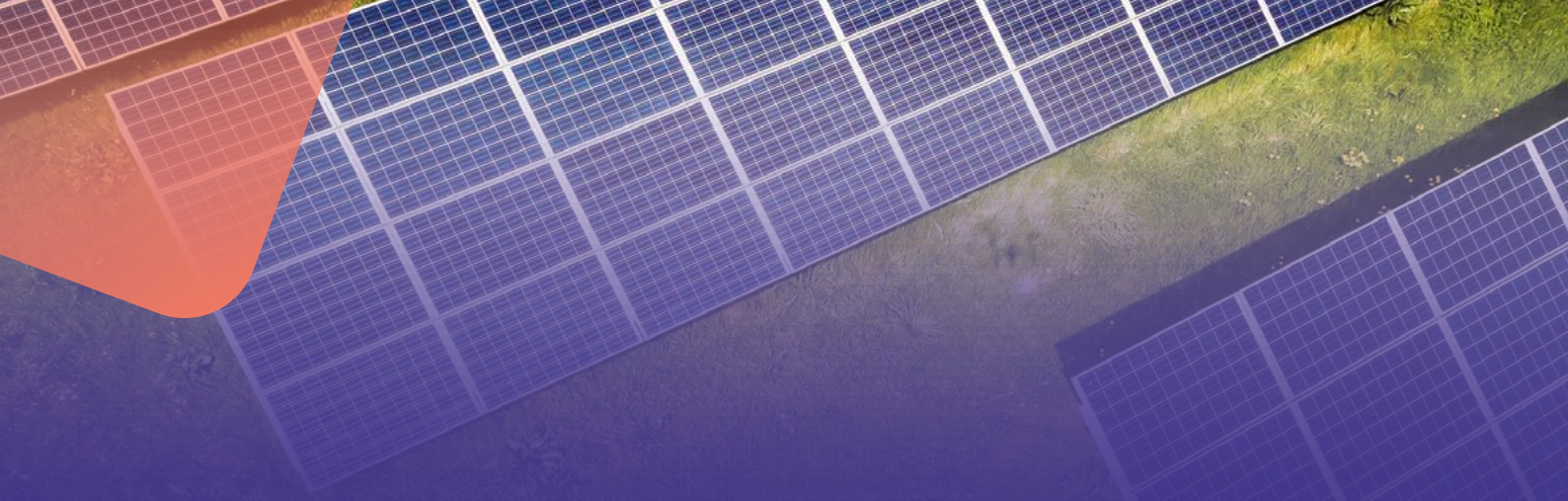
A major research focus was on sustainability and biodiversity. From 2021 to 2024, studies conducted by the consulting firm EMAT demonstrated that well-sited and managed photovoltaic plants not only reduce environmental impact but also encourage the growth of wildlife and plant life, effectively becoming biodiversity havens. Initiatives like installing nest boxes, creating ponds, and developing ecological corridors have proved that the biodiversity in these plants can surpass what was previously present in the surrounding area.

Socio-economic impact report

PHOTOVOLTAICS SIGNIFICANTLY BOOSTS LOCAL EMPLOYMENT BY UP TO 13.6% AND RAISES MUNICIPAL REVENUES BY MORE THAN 10%.

The Socio-economic Impact Report on Photovoltaics, developed in partnership with Carlos III University of Madrid and Complutense University, offers a thorough analysis of how solar plants boost economic and social development in the municipalities where they are located. Key findings from 2024 include:

- Employment: a rise of 7% to 13.6% during the construction phase.
- Population: a 3% to 8% increase in the total population, particularly among those of working age.
- Business activity: growth of 2.6% to 3.5% in the number of registered companies.



Optimise your market revenue

As one of the leading agents representing producers in Spain, we work to ensure that the production of more than 16,500 renewable energy plants like yours reaches homes and businesses.

We are currently the primary representative of photovoltaic producers in Spain.

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- Property and income: a 3% increase in average house prices and a 0.5% to 1% rise in household income.
- Municipal revenue: a 9% to 13.5% boost in tax collections from levies such as ICIO (Tax on Constructions, Installations and Works), IAE (Tax on Economic Activities), or IBI (Property Tax).
- Municipal expenditure: a 4.4% to 9.5% increase in public service spending.

These findings confirm that photovoltaics serves as a catalyst for socio-economic rejuvenation in rural areas, aiding in population retention and stimulating economic activi

Employment, diversity and inclusion

In 2024, UNEF collaborated with BBVA and EDP to develop the Employment and Diversity in the Photovoltaic Sector Report, which is set to be unveiled at GENERA 2025. The study examines the creation of quality jobs, talent development within the sector, and the extent of inclusion of vulnerable groups and women in the value chain. It will present proposals to enhance equal opportunities, provide specialised training, and retain talent in this rapidly expanding sector.

6.6. UNEF PARTNERS

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