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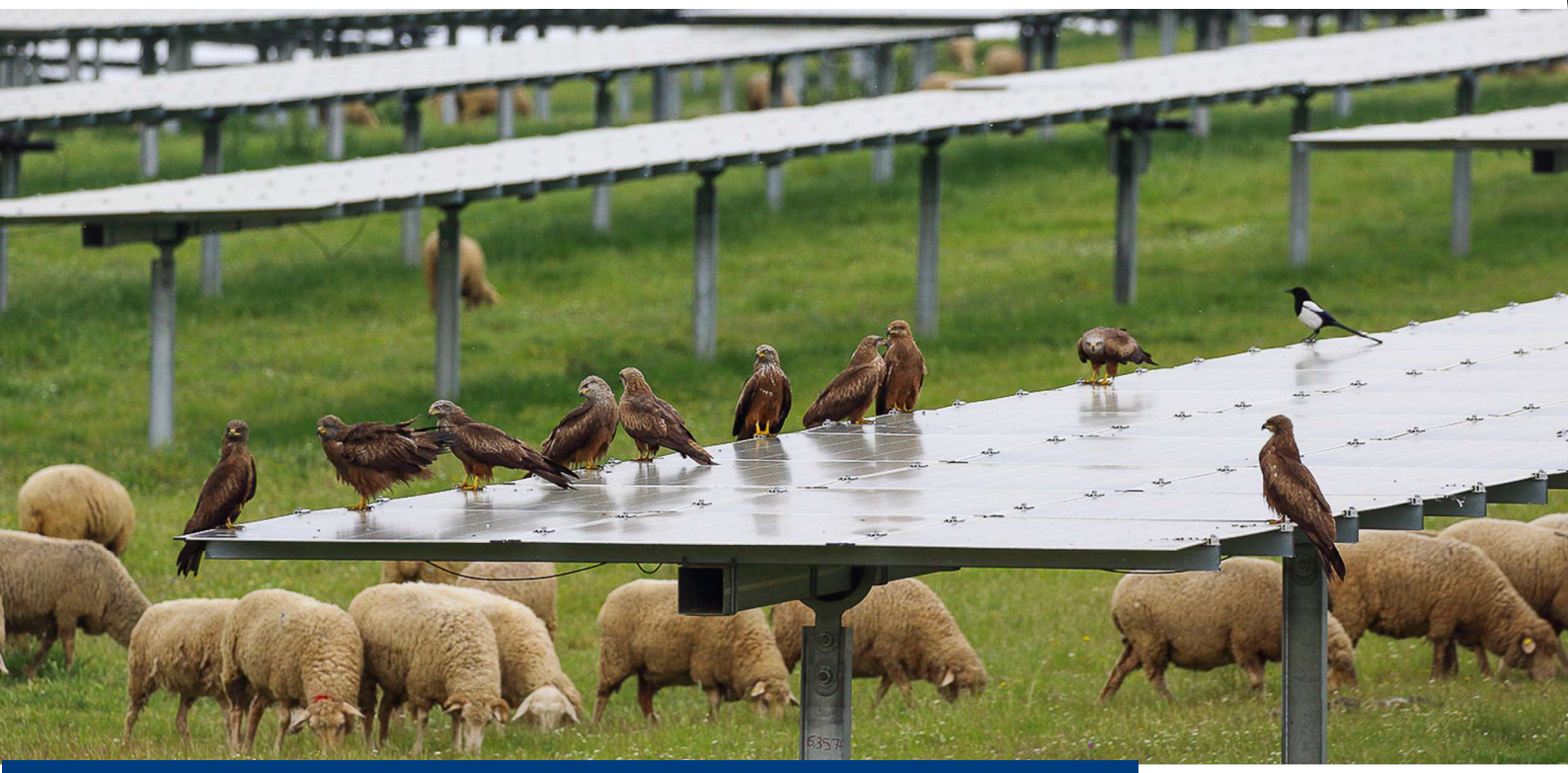
Photovoltaic Power Systems Programme



Task 1 Strategic PV Analysis and Outreach

PVPS

National Survey Report of PV Power Applications in Spain 2022

UNEF
Unión Española Fotovoltaica

What is IEA PVPS TCP?

The International Energy Agency (IEA), founded in 1974, is an autonomous body within the framework of the Organization for Economic Cooperation and Development (OECD). The Technology Collaboration Programme (TCP) was created with a belief that the future of energy security and sustainability starts with global collaboration. The programme is made up of 6.000 experts across government, academia, and industry dedicated to advancing common research and the application of specific energy technologies.

The IEA Photovoltaic Power Systems Programme (IEA PVPS) is one of the TCP's within the IEA and was established in 1993. The mission of the programme is to "enhance the international collaborative efforts which facilitate the role of photovoltaic solar energy as a cornerstone in the transition to sustainable energy systems." In order to achieve this, the Programme's participants have undertaken a variety of joint research projects in PV power systems applications. The overall programme is headed by an Executive Committee, comprised of one delegate from each country or organisation member, which designates distinct 'Tasks,' that may be research projects or activity areas.

The IEA PVPS participating countries are Australia, Austria, Belgium, Canada, Chile, China, Denmark, Finland, France, Germany, Israel, Italy, Japan, Korea, Malaysia, Mexico, Morocco, the Netherlands, Norway, Portugal, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, and the United States of America. The European Commission, Solar Power Europe, the Smart Electric Power Alliance (SEPA), the Solar Energy Industries Association and the Cop- per Alliance are also members.

Visit us at: www.iea-pvps.org

What is IEA PVPS Task 1?

The objective of Task 1 of the IEA Photovoltaic Power Systems Programme is to promote and facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of PV power systems. Task 1 activities support the broader PVPS objectives: to contribute to cost reduction of PV power applications, to increase awareness of the potential and value of PV power systems, to foster the removal of both technical and non-technical barriers and to enhance technology co-operation. An important deliverable of Task 1 is the annual "Trends in photovoltaic applications" report. In parallel, National Survey Reports are produced annually by each Task 1 participant. This document is the country National Survey Report for the year 2022. Information from this document will be used as input to the annual Trends in photovoltaic applications report.

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COVER PICTURE

FRV, Planta Solar Fotovoltaica La Solanilla (Trujillo)

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1 INSTALLATION DATA

The PV power systems market is defined as the market of all nationally installed (terrestrial) PV applications with a PV capacity of 40 W or more. A PV system consists of modules, inverters, batteries and all installation and control components for modules, inverters and batteries. Other applications such as small mobile devices are not considered in this report.

For the purposes of this report, PV installations are included in the 2022 statistics if the PV modules were installed and connected to the grid between 1 January and 31 December 2022, although commissioning may have taken place at a later date.

1.1 Applications for Photovoltaics

Over the last five years, Spain has increased its capacity exponentially adding more than 24.175 MWdc to the grid. Since 2019 the accumulated capacity increased from 6.306 MW in 2018 to 30.103,2 MW in 2022.

The year 2022 witnessed the highest achievement in the history of the photovoltaic (PV) sector in Spain adding a total of 8.620MWdc of new capacity.

In terms of ground-mounted plants, the installed capacity reached 23.804,4 GWdc, connecting 5.612,4 MWdc in only one year. The high spot market prices, together with the search for energy sovereignty and the auctions held in previous years, have been the basis for this growth.

The self-consumption sector also experienced a remarkable year, with a staggering increase of over 100%, resulting in the installation of 3.008,4 MWdc. This accounts for approximately half of the overall photovoltaic capacity. The industrial sector accounted for 47% of the new self-consumption installed capacity, followed by the residential sector (32%), while the commercial sector accounted for 20% of new installations. It is estimated that 1% of the self-consumption installations are off-grid.

1.2 Total photovoltaic power installed

The Transmission System Operator, Red Eléctrica de España (REE), has reported that the utility-scale PV capacity connected to the grid reached 23.804,4 MWdc in 2022, with an additional 5.612,4 MWdc of new centralized PV capacity.

However, this figure only accounts for utility-scale installations and does not include off-grid or self-consumption systems. UNEF, with the support of national providers and installer companies, has estimated a total installed PV capacity of 3.008,4 MWdc in 2022, as explained below

Table 1: Annual PV power installed during calendar year 2022

		Installed PV capacity in 2022 [MW]	AC or DC
	Decentralized	2.978,3	DC
	Centralized	5.612,4	DC
	Off-grid	30,1	DC

	Total	**8.620,8**	**DC**

According to REE's publication, the PV capacity connected to the grid in 2022 was reported as 5.612,4 MWdc (4.677 MWac), indicating the installation of utility-scale capacity during that year. By considering UNEF associates' estimations, the total off-grid installed capacity amounts to approximately 8.620,8 MWdc (7.184 MWac).

Table 2: PV power installed during calendar year 2022

			Installed PV capacity [MW]	Installed PV capacity [MW]	AC or DC
Grid-connected	BAPV	Residential	2.978,3	962,7	(DC)
		Commercial		601,7	(DC)
		Industrial		1.413,9	(DC)
	BIPV	Residential	N/A		
		Commercial			
		Industrial			
	Utility-scale	Ground-mounted	5.612,4	5.612,4	(DC)
		Floating			
		Agricultural			
Off-grid		Residential	30,1	30,1	(DC)
		Other			
		Hybrid systems			
Total			8.620,8		(DC)

Table 3: Data collection process

If data are reported in AC, please mention a conversion coefficient to estimate DC installations.	All figures are in DC.
Is the collection process done by an official body or a private company/Association?	Data collection has been done by official institutions (CNMC, REE, OMIE), Ministry of Ecological Transition and a private association (UNEF)
Link to official statistics (if this exists)	www.unef.es www.ree.es www.cnmc.es

	www.omie.es https://energia.gob.es/electricidad/energias-renovables/Paginas/registro-administrativo.aspx
Other	The figures from UNEF have been collected by the information supplied by their members.

Table 4: The cumulative installed PV power in 4 sub-markets

Year	Off-grid [MW]	Grid-connected distributed [MW]	Grid-connected centralized [MW]	Total [MW]
2010				4.595
2011				5.080
2012				5.439
2013				5.566
2014		26,4	5614,8	5.641,2
2015		85,2	5620,8	5.706
2016		151,2	5626,8	5.778
2017		297,6	5630,4	5.928
2018		580,8	5.725,2	6.306
2019	55,1	1.076,5	10.496,4	11.628
2020	7,2	1.839,6	13.995,6	15.842,4
2021	14,4	3.276	18.192	21.482,4
2022	30,1	6.268,7	23.804,4	30.103,2

REE provides the figure for the total PV capacity connected to the grid, specifically referring to the cumulative capacity of centralized grid-connected installations, adding an estimation on self-consumption (through surpluses discharged into the grid). This information is updated regularly and it may suffer some changes yearly.

In 2019 UNEF changed its methodology to collect distributed capacity. Current data collection estimating the new decentralized capacity is calculated by collecting information from producers and distributors and double checking with installers.

UNEF takes into account the cumulative installed capacity of PV systems, including self-consumption and off-grid installations. Therefore, the total cumulative PV capacity mentioned is determined by UNEF + REE data.

Table 5: Other PV market information

	2022
Number of PV systems in operation in your country	62.335 (cumulative ground-mounted) + 249.000 (new self-consumption installations in 2022)
Decommissioned PV systems during the year [MW]	N/A
Repowered PV systems during the year [MW]	N/A

The data regarding ground-mounted plants was collected from the Administrative Register of Electricity Production Facilities of the Ministry of Ecological Transition. On the other hand, the number of decentralized installations (self-consumption) has been carried out by UNEF by contacting manufacturers and contrasting this information with distributors and installers.

Table 6: PV power and the broader national energy market

	Data	Year
Total power generation capacities [GW]	119,4 GW ac [1] 143,28 GW dc	2022
Total renewable power generation capacities (including hydropower) [GW]	74,1 GW ac [2] 88,92 GW dc	2022
Total electricity demand [TWh]	250.421 GWh [3]	2022
New power generation capacities installed [GW]	119 GW ac [4] 142,8 GW dc	2022
New renewable power generation capacities (including hydropower) [GW]	8,4GW ac [5] 10 GW dc	2022
Estimated total PV electricity production (including self-consumed PV electricity) in [GWh]	33.893 GWh [6]	2022
Total PV electricity production as a % of total electricity consumption	10,1% [7]	2022
Average yield of PV installations (in kWh/kWp)		

[1] TSO - Generation webpage

[2] TSO - Generation webpage

[3] TSO Electric System Report 2022

[4] TSO Electric System Report 2022

[5] TSO Electric System Report 2022 + Self Consumption (SC) estimated by UNEF

[6] TSO - Generation webpage (27.902 GWh) + Estimated using SC capacity given by UNEF, 1500 equivalent hours for the accumulated capacity and 750 for the capacity installed in 2022 (5991 GWh)

[7] TSO webpage, only includes ground mounted

1.3 Key enablers of PV development

Table 7: Information on key enablers.

	Description	Annual Volume	Total Volume	Source
Decentralized storage systems In MWh	During 2021 the government elaborated the storage and the green hydrogen strategies with the aim of increasing the development of these two technologies in the upcoming years.	-	1382,84 MWh in 2022	ANÁLISIS DEL ESTADO ACTUAL DEL ALMACENAMIENTO DETRÁS DEL CONTADOR EN ESPAÑA - UNEF
Residential Heat Pumps	In August 2022 on August 3, 2022 Spain published the first call for the Incentive Programs for heating and cooling network projects using renewable energy sources.	438.326 new plants in 2021	5.000.150 plants in 2021	https://estadisticas-bombasdecalor.idae.es/
Electric cars		13.212 new registrations in 2023	359.283 electric cars by May 2023	https://alternative-fuels-observatory.ec.europa.eu/
Electric buses and trucks		252 buses + 160 trucks in 2023	606 buses + 203 trucks in 2023	https://alternative-fuels-observatory.ec.europa.eu/transport-mode/road/spain/vehicles-and-fleet
Other (up to you)				

2 COMPETITIVENESS OF PV ELECTRICITY

2.1 Module prices

Table 8: Typical module prices

Year	Lowest price of a standard module crystalline silicon	Highest price of a standard module crystalline silicon	Typical price of a standard module crystalline silicon
2022	-	-	0.22€/Wp

Average price for a 10-50 MW facility.

2.2 System prices

Table 9: Turnkey PV system prices of different typical PV systems

Category/Size	Typical applications and brief details	Current prices [€/W]
Off-grid 1-5 kW	A stand-alone PV system is a system that is installed to generate electricity to a device or a household that is not connected to the public grid.	1,67 – 1,75
Residential BAPV 5-10 kW	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity to grid-connected households. Typically roof-mounted systems on villas and single-family homes.	1,6 – 1,7
Residential BIPV 5-10 kW	Grid-connected, building integrated, distributed PV systems installed to produce electricity to grid-connected households. Typically, on villas and single-family homes.	-
Small commercial BAPV 10-100 kW	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity to grid-connected commercial buildings, such as public buildings, multi-family houses, agriculture barns, grocery stores etc.	1,12
Small commercial BIPV 10-100 kW	Grid-connected, building integrated, distributed PV systems installed to produce electricity to grid-connected commercial buildings, such as public buildings, multi-family houses, agriculture barns, grocery stores etc.	-
Large commercial BAPV	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity to grid-connected large	0,67

100-250 kW	commercial buildings, such as public buildings, multi-family houses, agriculture barns, grocery stores etc.	
Large commercial BIPV 100-250 kW	Grid-connected, building integrated, distributed PV systems installed to produce electricity to grid-connected commercial buildings, such as public buildings, multi-family houses, agriculture barns, grocery stores etc.	-
Industrial BAPV >250 kW	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity to grid-connected industrial buildings, warehouses, etc.	
Small centralized PV 1-20 MW	Grid-connected, ground-mounted, centralized PV systems that work as central power station. The electricity generated in this type of facility is not tied to a specific customer and the purpose is to produce electricity for sale.	0,72
Large centralized PV >20 MW	Grid-connected, ground-mounted, centralized PV systems that work as central power station. The electricity generated in this type of facility is not tied to a specific customer and the purpose is to produce electricity for sale.	0,59 – 0,62
Other categories existing in your country. Examples could be: **Hybrid diesel-PV** **Floating Centralized PV** **Agricultural PV** **Industrial BIPV**		

Table 10: National trends in system prices for different applications

Year	Residential BAPV Grid-connected, roof-mounted, distributed PV system 5-10 kW **[€/W]**	Small commercial BAPV Grid-connected, roof-mounted, distributed PV systems 10-100 kW **[€/W]**	Large commercial BAPV Grid-connected, roof-mounted, distributed PV systems 100-250 kW **[€/W]**	Centralized PV Grid-connected, ground-mounted, centralized PV systems 10-50 MW **[€/W]**
2022	1,7	1,1	0,67	0,6

2.3 Financial Parameters and specific financing programs

Table 11: PV financing information in 2022

Different market segments	Loan rate [%]
Average rate of loans – residential installations	7.05
Average rate of loans – commercial installations	6
Average cost of capital – industrial and ground-mounted installations	7.7

2.4 Specific investments programs

Utilities, independent retailers and big self-consumption installers have acquisition or leasing programs easing the installation of PV rooftop. The company bears the investment, builds the facility (or contracts it to a third party) that is then repaid through a monthly fee paid by the consumer/ client. Once the facility is repaid, the consumer/ client becomes the owner of the facility but before that, the owner is the installer.

Also, the Spanish Government's Institute for the Diversification and Saving of Energy (IDAE), channel public funds and financial programmes for renewables. It also provides advisory and coordination services in all phases of the project. IDAE provides financing schemes that could be destinated to cover fees in the design and construction phases, project engineering costs, project construction, inter-calary and accrued VAT. Currently there are three different financial models:

- Open system: allows the adaptation of the contracts, starting from a base model, to the particularities of each singular project.
- Variable remuneration: the IDAE's remuneration based on the energy performance of the installation allows the developer to modulate the financial costs of the project.
- Integral solution: allows the developer to have 100% financing of the investment costs of an energy project (including VAT and intercalary), with the technical advice and experience of the IDAE in the development of this type of projects.

2.5 Merchant PV / PPA / CPPA

All large-scale solar capacity commissioned during 2020 (3.5 GW), 2021 (4.3 GW) and 2022 (5.3 GW), has been developed without any type of public aid. PV capacity has been developed mostly through PPAs, auctions or merchant projects. The stability offered by Power Purchase Agreements is now more valuable than ever.

For the fourth consecutive year, in 2022 Spain was the most active renewable PPA market in Europe, both in terms of volume contracted and number of agreements signed. According to multiple reports, during 2022 Spain closed more than 3.2 GW of renewable energy through PPAs, where PV has occupied the largest share of the market.

Spot market prices have soared during 2022. According to OMIE (Spanish designated market operator), average daily wholesale market prices stood at €168 MWh, reaching a maximum of €700 MWh, which has been cushioned by the introduction of the gas cap, which has limited

electricity prices. High gas prices (a technology that tends to set market prices) have accelerated the installation of photovoltaic systems that provide price stability and reinforce energy sovereignty.

2.6 Additional Country information

Table 12: Country information

Retail electricity prices for a household [€/MWh]	285-259 €/MWh (10kW, regulated – free market)
Retail electricity prices for a commercial company [€/MWh]	190 €/MWh
Retail electricity prices for an industrial company [€/MWh]	158 €/MWh
Liberalization of the electricity sector	The electricity sector was liberalized in 1997. Retail was separated from distribution network ownership in 2009. Currently there are 751 energy retailers, 334 DSO and only one TSO (Red Electrica)

Data regarding the retail electricity prices for a household and commercial companies was collected from the Regulator (CNMC). Data regarding the current number of retailers and distribution system operators was collected from the Spanish regulator webpage (CNMC).

The total population registered in Spain in 2022 was 47.435.597 inhabitants, according to the National Institute of Statistics.

3 POLICY FRAMEWORK

This chapter describes the support policies aiming directly or indirectly to drive the development of PV. Direct support policies have a direct influence on PV development by incentivizing or simplifying or defining adequate policies. Indirect support policies change the regulatory environment in a way that can push PV development.

Table 13: Summary of PV support measures

Category	Residential		Commercial + Industrial		Centralized	
Measures in 2022	**On-going**	**New**	**On-going**	**New**	**On-going**	**New**
Feed-in tariffs	-	-	-	-	-	-
Feed-in premium (above market price)	-	-	-	-	-	-

Capital subsidies	Yes	Yes	Yes	Yes	Yes-	Yes
Green certificates	-	-	-	-	-	-
Renewable portfolio standards with/without PV requirements	-	-	-	-	-	-
Income tax credits	Yes	Yes	-	-	-	-
Self-consumption	Yes	Yes	Yes	-	-	-
Net-metering	-	-	-	-	-	-
Net-billing	Yes	-	Yes	-	-	-
Collective self-consumption and delocalized net-metering	Yes	-	Yes	-	-	-
Sustainable building requirements	-	Yes	Yes	-	-	-
BIPV incentives	-	-	-	-	-	-
Merchant PV facilitating measures	Yes		Yes			
Other (specify)	-	-	-	-	-	-

3.1 National targets for PV

National climate objectives are set in line with European objectives, through the National Energy and Climate Plans (NECPs). The Spanish NECPs sets a specific target of 39 GWac for photovoltaic energy generation by 2030. Spanish NECP is currently under review.

The trends, developed from the current growing rates of solar PV in Spain show that this target will be achieved earlier than expected. Nevertheless during 2023 this will be reviewed in line with the new EU objectives.

Currently there is a new draft on (NECPs) targets, where the government sets 76 GW of global target for PV by 2030. 57GW for ground-mounted plants and other 19GW for self-consumption. Additionally, the draft points to 22GW of storage, and 11GW of hydrogen.

3.2 Direct support policies for PV installations

3.2.1 Specific remuneration regime

The support scheme for renewables called “specific remuneration regime” approved by Royal Decree 413/2014 is still in place for existing plants (built before 2019). In this scheme, this specific remuneration is defined as a complementary retribution to the wholesale market in order to allow renewable technologies to achieve a “reasonable profitability”.

This “reasonable profitability” is defined as the retribution on the electricity generation activity that a well-managed renewable plant would have. In order to determine the regulated incomes to be given, a set of theoretical standard installations with standard costs was developed. Current reasonable profitability values are:

- 7.09% for 2020-25 for plants built after retroactive reform of 2013.
- 7.4% for 2020-31 for plants built before retroactive reform of 2013 if they renounce to international arbitration processes.

In 2022, to foster the development of future markets, a modification has been introduced in the Specific remuneration regime, including in the market price adjustment, prices for a portfolio of futures prices (month, Quarter, year)

3.2.2 Investment grants for ground mounted PV in Canary and Balearic Islands

To foster development of renewables in the islands, investment grants were given through auctions celebrated in 2020 both to Balearic and Canary Islands projects. In the Canary Islands 65 PV projects with a total power of 255 MW were awarded grants and in the Balearic Islands there were awarded 44 PV projects with a total power of 168 MW.

3.2.3 BIPV development measures

The European REPower EU program sets a target for all buildings to have solar panels by 2030. The following milestones have been set:

- New public and commercial buildings must implement solar panels from 2026.
- All existing large (over 250 m2) public and commercial buildings must incorporate photovoltaics from 2027.
- From 2028 all new government and commercial buildings (whatever their size) must have solar power.
- By 2030 all new buildings must have solar panels.

These measures will soon be mandatory in all the EU countries, but up to date they are not in force.

3.2.4 Merchant PV development measures

The marginal pricing system is the only incentive for most renewables. The fact that the most expensive technologies set the reference price in the daily market, makes photovoltaic technology to be very attractive due to its price.

Until December 31, 2023, the remuneration of non-greenhouse gas emitting technologies will be reduced. The reduction will be proportional to the higher income obtained by these facilities as a result of the extraordinary incomes (so called windfall-profits) receiver due to the high prices of gas that have risen the wholesale electricity prices.

3.3 Self-consumption measures

Table 14: Summary of self-consumption regulations for small private PV systems in 2022

PV self-consumption	1	Right to self-consume	Yes
	2	Revenues from self-consumed PV	Savings on the electricity bill
	3	Charges to finance Transmission, Distribution grids & Renewable Levies	There are charges to finance Transmission, Distribution grids & Renewable Levies but they

			are imposed on energy consumed from the grid not on self-consumed energy
Excess PV electricity	4	Revenues from excess PV electricity injected into the grid	Yes . The wholesale market price at that hour
	5	Maximum timeframe for compensation of fluxes	Month
	6	Geographical compensation (virtual self-consumption or metering)	Yes. Only nearby PV facilities (not virtual)
Other characteristics	7	Regulatory scheme duration	Not limited by regulation
	8	Third party ownership accepted	Yes
	9	Grid codes and/or additional taxes/fees impacting the revenues of the prosumer	No
	10	Regulations on enablers of self-consumption (storage, DSM…)	Yes
	11	PV system size limitations	There is a soft limitation on the sizes of AC PV systems. Above 10 KW permitting complexity increases. Above 100 KW permitting complexity also increases. And if the installation requires high voltage permitting complexity increases even more.
	12	Electricity system limitations	Network access permits are required for PV rooftop facilities above 15 kW if they inject excess electricity to the grid
	13	Additional features	

3.3.1 Next Generation subsidies for self-consumption

During 2021, the Council of Ministers approved the first of the measures of the Recovery Plan for renewable energies granting 660 million euros (expandable to 1.320 million) on aid for self-consumption facilities, behind-the-meter storage and air conditioning with renewable energies. An initial budget of 450 million euros (expandable up to 900 million) was assigned for self-consumption.

3.3.2 Behind-the-meter storage systems

Within the same legislative act before mentioned, in 2021 the Spanish Council of Ministers assigned a budget of 110 million euros (expandable up to 220 million) for storage behind the meter. These grants are aimed at the installation of decentralized storage systems. The subsidies for companies vary between 45% and 65%, depending on their size, while individuals, administrations and the third sector benefit from 70%.

3.3.3 Local taxes exemptions

Most municipalities have local taxes exemptions to promote PV self-consumption. These include property tax, construction tax and economic activities tax.

3.4 Collective self-consumption, community solar and similar measures

During the last years, Spain has launched several plans for the development of collective self-consumption, mainly through aid to Energy Communities and Community Transformation Offices.

3.4.1 Energy Communities (EC)

An energy community (EC) is a legal entity whose objective is the use of local renewable resources by partners or members, with the aim of reinvesting the benefits generated in the community itself, which may be environmental, social or economic benefits, but never focused on obtaining financial gains.

At the end of 2021, and with the aim of promoting the creation of the ECs, the Spanish Ministry of Energy announced 100 million euros to support the development of Energy Communities. These grants are intended to subsidize, on a non-refundable basis, those activities for the start-up of singular pilot projects carried out by energy communities, strengthening, promoting, encouraging and supporting the execution of this type of projects. These will be granted by the Spanish Government's Institute for the Diversification and Saving of Energy (IDAE), once it is verified that the execution of the project and the investment have been carried out. During the year 2022, more than 80 million euros were allocated.

3.4.2 Community Transformation Offices (OTC)

The Community Transformation Offices (OTC) are physical and/or virtual spaces that will disseminate information about Energy Community projects providing advice and support.

In 2022, the Spanish Government approved the bases for receiving grants to develop Community Transformation Offices (CTOs). These grants, which are non-refundable, aim to promote the start-up of these OTCs, which will make it possible to promote energy communities. The first call, with a budget of 20 million euros, was open for applications from November 28 to January 23, 2023.

3.5 Tenders, auctions & similar schemes

3.5.1 Renewable Energy Economic Regime (REER auctions)

In 2020 the Renewable Energy Economic Regime (REER) was introduced in the Spanish market. This regime is an auction-based scheme based on the recognition of a long-term price for the energy generated.

In January 2021, the first auction was held, offering 3.000 MWac in a mixed scheme between technology-neutral and specific auctions with a quota of 1.000 MW for photovoltaic, another 1.000 MW for wind power and 1.000 MW technologically neutral. In this auction, 2.034 MW were allocated to photovoltaic, at an average price of 24.5 €/MWh. Projects were to be developed and operative by 2023.

In October 2021 the second REER auction offered 3.300 MWac of new capacity. This auction defined quotas of 700MW for PV, 600 MW for "*accelerated availability*" (photovoltaic and wind) and 300 MW for local distributed photovoltaic. In addition to these quotas, 200 MW were allocated on a technology-neutral basis and without conditions. In this second auction, 838 MW was allocated to the PV quota, 22 MW to PV from the "*accelerated availability*" quota, and 6 MW to local distributed PV. The average price for solar PV was 31.6 €/MWh.

In October 2022, the third auction was held, offering 500 MWac, of which 140MW were allocated to local distributed PV. Out of a total of 140MW, only 31 MW were awarded to 6 companies. The average price awarded in PV was 53.87 €/MWh, significantly higher than that of the two previous auctions, due to the evolution and prospects of electricity market prices and electricity futures prices.

Finally, in November 2022, the fourth REER auction offered 1.500MWac for wind power and 1.800 MW for solar PV. With a reserve price of around €45.12/MWh, the photovoltaic quota ended empty. This may hap happened due to the high reserve price set by the government (45,12 EUR/MWh), was well below the sector's expectations (60 EUR/MWh), added to elevated merchant prices and high inflation rates.

3.5.2 PPA risk hedge

In addition, the Government approved in 2020 new legislation to reduce the electricity costs of big consumers obliging these agents to sign renewable PPAs. The scheme introduces exemptions for big consumers on the payment of certain electricity charges conditioned to the signature of a renewable PPA for 10% of their consumption. To ease the signature of these PPAs, a public insurance company will cover the risks of the PPA.

3.6 Other utility-scale measures including, floating and agricultural PV

There are no new support measures specifically for utility-scales projects in Spain.

3.7 Social Policies

3.7.1 AID FOR RENEWABLE ENERGIES IN SELF-CONSUMPTION, STORAGE AND THERMAL ENERGY IN THE RESIDENTIAL SECTOR (RD 477/2021. PRTR)

The Government approved a Royal Decree (477/2021) which promotes the development of renewable energies, the control of consumption and the promotion of industry through direct

aid to the autonomous communities. It establishes six incentive programs for self-consumption, storage and thermal uses of renewable energies. These programs will be in force until December 31, 2023 and have an initial financing of 660 million euros, expandable up to 1.320 million euros. The Ministry for Ecological Transition and the Demographic Challenge, through the IDAE, will coordinate and supervise the aid managed by the autonomous communities. This policy framework includes 5 specific programs for FV self-consumption and storage:

Incentive Program 1: For the implementation of self-consumption installations, with renewable energy sources, at the service sector, with or without storage.

Incentive program 2: For the implementation of self-consumption facilities, with renewable energy sources, in other productive sectors of the economy, with or without storage.

Incentive program 3: For the implementation of storage in self-consumption facilities, with renewable energy sources, already existing in the service sector and other productive sectors.

Incentive program 4: For the implementation of self-consumption facilities, with renewable energy sources, in the residential sector, public administrations and the third sector, with or without storage.

Incentive program 5: For the implementation of storage in self-consumption facilities, with renewable energy sources, already existing in the residential sector, public administrations and the third sector.

3.7.2 SUPPORT FOR INNOVATIVE ENERGY STORAGE PROJECTS HYBRIDIZED WITH ELECTRICITY GENERATION FACILITIES FROM RENEWABLE ENERGY SOURCES, WITHIN THE PERTE ERAH.

In January 2023, the first call for innovative energy storage projects hybridized with renewable energy was launched. This program subsidizes part of the self-consumption projects that accounts with hybrid storage.

The purpose of this call is to promote the deployment of energy storage, contributing to the energy transition and, specifically, to provide new flexibility to the energy sector, increasing the integration of renewable energies.

The Call for Proposals will allocate 150,000,000 € of aid to energy storage projects, of which 20,000,000 € and 6,000,000 € will be allocated to projects located in the Canary and Balearic Islands, respectively. They must also include complementary measures for the improvement or environmental recovery of the environment in which the facilities are implemented.

The principle of technological neutrality will be applied, contemplating all energy storage projects that enable the large-scale commercial deployment of energy storage, without any technology being restricted in terms of technological maturity level. Exceptions are projects using hydrogen.

3.8 Indirect policy issues

3.8.1 Rural electrification measures

There are not any rural electrification measure currently going on in Spain.

3.8.2 Support for electricity storage and demand response measures

In 2020, the government launched the hydrogen roadmap as a hydrogen storage development strategy. It sets targets of 4GW of installed electrolyzer capacity by 2030 and a series of milestones in the industrial sector, mobility and the electricity sector, for which it will be necessary to mobilize investments estimated at 8.9 billion euros during the period 2020-2030. However, as an intermediate milestone until the 4GW target is reached, it is estimated that by 2024 it would be possible to have an installed capacity of electrolyzers of between 300 and 600 MW.

In march 2022 it was launched the first call for grants for innovative energy storage R&D projects. The purpose of this call is to promote the technological development of energy storage technologies and to encourage their deployment.

The Call will allocate €50.000.000 in aid to energy storage projects with the aim of advancing their technological development. To this end, it will finance experimental development projects, which could be prototypes or pilot projects, of any technology that is at a sufficient level of technological maturity.

This is one of the first calls of a complete program (called PERTE ERHA) of instruments and measures to develop technology, knowledge, industrial capacities and new business models that will mobilize an investment of more than 16.300 million euros. The economic support will be granted through competitive calls to select the best projects.

Likewise, through the deployment of this aid mechanism, progress will be made towards achieving the objectives of the Energy Storage Strategy, which aims to reach a storage capacity of 20 GW by 2030.

3.8.3 Support for encouraging social acceptance of PV systems

There are not any policy encouraging social acceptance of PV systems.

3.8.4 Other support measures

The European Commission (EC) has presented 2 measures that will have an impact on the photovoltaic industry in Spain: The Net-Zero Industry Act (as a response to the US Inflation Reduction Act) and the REPower EU (as a response to the energy dependence).

The Net-Zero Industry Act proposal aims to boost the production capacity of renewable energy technologies in Europe. This proposal seeks to facilitate financial, administrative and regulatory support for the rapid deployment of clean technologies in Europe. The proposal sets targets for different technology sectors, including a 40% scaling-up effort in solar photovoltaics. In addition, it creates the figure of zero balance resilience projects, aimed at achieving the targets set and improving the technological and industrial resilience of the supply chain. The proposal also includes measures to accelerate the project pipeline, establishes CO2 injection capacity targets and offers regulatory, financial, market access and skilled labour support.

Also, the EC launched the REPowerEU Plan to curb price volatility and the dependence on Russian fossil fuels. The plan proposes measures on energy savings, supply diversification and increasing renewable energy by 2030. Solar PV is presented as a key tool to meet the targets set by the REPower EU Plan, increasing technology deployment rates by 20%.

This roadmap aims to accelerate the deployment of renewable energies, surpassing the target previously set by the "Fit for 55" package by increasing the share of renewable energy sources in the EU energy mix from 40% to 45%. The Plan creates specific programs designed to boost the development of the photovoltaic industry, including:

- The EU Solar Energy Strategy, proposing to double solar PV capacity by 2030.
- The rooftop solar initiative where a legal obligation is imposed to install solar panels on new public, commercial and residential buildings.
- A recommendation to simplify and shorten permitting processes, as well as an amendment to the Renewable Energy Sources Directive to recognize renewable energy sources as being in the public interest.

In the context of implementing the REPower Plan, the EU Solar Strategy identifies the barriers and challenges to the development of solar energy and seeks to increase photovoltaic capacity by 43%. The Solar Strategy sets a target of installing 400 GWdc (320 GWac) by 2025, reaching 750 GWdc (600 GWac).

In order to achieve part of the objectives of the Solar Strategy Communication, the European Commission (EC) proposed the European Solar Roof Initiative. This initiative aims to increase renewable energy shares and streamline procedures for rooftop solar installations. It also makes it mandatory to install solar systems on all new public and commercial buildings larger than 250 m², starting in 2026. This obligation would be extended in 2027 to all buildings with more than 250 m², and in 2029 to all new residential buildings.

In line with the EC Solar Strategy Communication, the European Parliament approved in March 2023 a proposal to reform the Energy Performance of Buildings Directive, which includes a proposal on solar roofs. Specifically, the solar rooftop amendment tabled by the European Parliament sets a target of generating 19 TWh of rooftop solar power in the first year, equivalent to an increase in capacity from 16 to 19 GW. By 2025, the aim is to reach a rooftop solar power generation of 58 TWh, i.e. a capacity of 50.7 to 58 GW.

3.9 Financing and cost of support measures

Specific remuneration regime is financed through charges in the electricity tariff. Grant subsidies are partially financed thanks to the European Regional Development Fund of the EU. Local taxes exemptions are financed by the municipalities.

Support measures to develop PV have been develop mainly for self-consumption

- The self-employed are beneficiaries of programs to promote self-consumption and may deploy self-consumption installations in a place of work other than their home.
- Promoting organizations providing energy services or investment by third parties, thus facilitating the installation of self-consumption when the consumer does not have the capacity to make the investment.

Also in 2022, a program of fiscal deductions for the installation of pv for self-consumption modalities was approved within the framework of deductions for measures to improve energy efficiency in buildings.

3.10 Grid integration policies

3.10.1 Grid connection policies

The right of third party access to the transmission and distribution networks is one of the guiding principles of the liberalization of the Spanish electricity market.

Access to the transport grid is granted by the TSO to all subjects that are considered as suppliers: producers, system operator, market operator, distributors, energy traders,

consumers and system load managers. The TSO can only denny access if the grid doesn´t have enough capacity.

The price for the use of transmission networks is determined by a toll annually approved by the Government.

The necessary investment to connect to the grid is paid by the generator who wants to connect, but the ownership of the new installations developped to facilitate the connection will become property of the TSO´s (or DSO). If the new facilities developed are subject to additional use by another consumer and/or generator, the new user will contribute, for the proportional part of the use of the capacity of the facility, in the investments made by the first one.

The price for the use of distribution networks is determined by the network access toll, which is approved by the Government. In order to be able to request access to the distribution networks, a connection point must first be available under the technical conditions established by regulation.

The distribution system operator (DSO) may refuse access to the system only if it does not have the necessary capacity. The lack of capacity may only be justified by criteria of security, regularity or quality of supplies.

3.10.2 Grid access policies

Grid access is regulated throug tolls. Tolls are fixed by the government at the end of the previous year and partially payed by producers and retailers to finance half of the Market and System Operator costs. These costs are usually passed on to consumers.

The other half of the costs (in the case of transmission facilities) for financing the use of the network (operation an maintenance) are borned by the system. Neverheless, these costs are also passed on to consumers through the electricity bill throgh as “regulated costs” and are used to parcially remunerate the Market Operator and the System Operator.

4 INDUSTRY

4.1 Production of feedstocks, ingots and wafers (crystalline silicon industry)

Table 15: Silicon feedstock, ingot and wafer producer’s production information for 2022

Manufacturers (or total national production)	Process & technology	Total Production	Product destination	Price
-	Silicon feedstock [Tonnes]	0		
-	sc-Si ingots. [Tonnes]	0		
-	mc-Si ingots [Tonnes]	0		

-	sc-Si wafers [MW]	0		
-	mc-Si wafers [MW]	0		

4.2 Production of photovoltaic cells and modules (including TF and CPV)

Module manufacturing is defined as the industry where the process of the production of PV modules (the encapsulation) is done. A company may also be involved in the production of ingots, wafers or the processing of cells, in addition to fabricating the modules with frames, junction boxes etc. The manufacturing of modules may only be counted to a country if the encapsulation takes place in that country.

Total PV cell and module manufacture together with production capacity information is summarised in Table below.

Table 16: PV cell and module production and production capacity information for 2022

Cell/Module manufacturer (or total national production)	Technology (sc-Si, mc-Si, a-Si, CdTe, CIGS)	Total Production [MW]		Maximum production capacity [MW/yr]	
		Cell	Module	Cell	Module
Wafer-based PV manufactures					
Escelco	Mono-cristaline	0	5,6	0	70
Escelco	Poly-cristaline	0	0,48	0	0
Etc.					
Thin film manufacturers					
-		0	0	0	0
Cells for concentration					
BSQ Solar*		0	0,11148	0	2,5
Totals		0	**6,19148**	**0**	**72,5**

* The BSQ Solar data is from 2020 the have not agreed to disclose their productions this year

The cells are purchased in the international markets.

4.3 Manufacturers and suppliers of other components

- PV inverters (for grid-connection and stand-alone systems) and their typical prices: Most of the photovoltaic inverters used in Spain are of foreign origin. However, there are some national manufacturers.

- Storage batteries: Currently Spain does not have a solid battery industry. Most of the batteries used for storage are imported.
- Battery charge controllers: Although there are a few Spanish manufacturers of battery charge controllers, the major players in this industry are predominantly non-Spanish companies.
- DC switchgear: Spain is home to several companies specializing in the production of DC switchgear.
- Supporting structures: Spain is home to a large number of companies specializing in the manufacturing of support structures.
- BIPV products: There are many BIPV-investigation centres. There is at least one manufacturer of BIPV systems

Pannels	Trackers	Structure	Inverters	Switching	Transformer	Batteries
Atersa Aurinka BSQ Solar Escelco Ferrosolar (Silicio) Mondragón Asse. Onyx Solar	Braux BSQ Solar Trina (Nclave) Praxia PVH Soltec Stansol STI Norland	Alusín solar Braux Csolar Gonvarri solar Imedexsa INSO Aluminios Isigenere Magon Nclave Praxia PVH Solarstem Soltec Stansol STI Norland Sunfer Energy	GP Tech Ingeteam JEMA Energy Pwr. Electronics Zigor	Gave Ormazábal	DF Electric Eremu Faramax IESA IMEFY Ormazábal Suesa	Ampere Energy Cegasa Exide Tech. Hydra Redox Zigor

5 PV IN THE ECONOMY

This chapter aims to provide information on the benefits of PV for the economy.

5.1 Labour places

Table 17: Estimated PV-related full-time labour places in 2021*

Market category	Number of full-time labour places
Research and development (not including companies)	(There is not data available from this category. R&D roles are included under other the other categories)

Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D (manufacturers)	16.977
Distributors of PV products and installations (engineering, EPC, consulting, lawyers and distributors)	35.784
Other (producers and developers)	36.883
Total	**89.644**

*There is no available data from 2022 yet. This data is from 2021. We include direct, indirect, and induced labour places.

Table 18: Estimated PV-related full-time labour places in 2021*

Market category	Number of full-time labour places
Research and development (not including companies)	(There is not data available from this category. R&D roles are included under other the other categories)
Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D (manufacturers)	4.035
Distributors of PV products and installations (engineering, EPC, consulting, lawyers and distributors)	11.196
Other (producers and developers)	6.365
Total	**21.596**

In this table we have included the data corresponding to direct employment. We do not have data regarding the nature of the jobs.

5.2 Business value

Table 19: Rough estimation of the value of the PV business in 2022 (VAT is excluded)

Sub-market	Capacity installed [MW ac]	Average price [currency/Wp]	Value	Sub-market
Off-grid	30,1	1.7 €/Wp	51,2M€ = 30,1 * 1,7 * 1 *000 000*	*51,2M€*
Grid-connected distributed	2978,3	1 €/Wp	2978,3M€= 2482 * 1.2 * 1 000 000	2978,3M€
Grid-connected centralized	5612,4	0.6 €/Wp	3367,44M€= 5612,4 * 0.6€* 1 000 000	3367,4M€

Value of PV business in 2022	= 6396,9M€

6 INTEREST FROM ELECTRICITY STAKEHOLDERS

6.1 Structure of the electricity system

This is the electricity industry landscape in Spain:

- Structure – Since the liberalization of the energy market, activities must be formally separated. By law, it is mandatory to separate regulated activities (system operation, market operation, transmission and distribution) and liberalized activities (production, commercialization and energy recharge services). EU Directives claim for the separation of property model as the most effective way to promote investments in infrastructure in a non-discriminatory manner, fair access to the network for new operators and market transparency
- Companies working with both liberalized and regulated activities must formally create independent societies that should not share name, logo nor finances. Vertically integrated companies under the same society are formally banned.
- Retailers and network businesses – "Red electrica" (The transmitter and TSO) does not take part in the production or retail business. Some distribution companies also take part in the retail business but, as said before, the two business need to be formally separated among the company.
- Ownership – private – public (state owned or municipal): The generators, retailer and distributors are mostly privately-owned company. On the other hand, Spanish TSO "Red electrical" is 20% state-owned and 80% privately-owned
- Electricity market regulator -The Spanish regulator is the National Commission of Markets and Competency (CNMC)

6.2 Interest from electricity utility businesses

Historically, regulatory instability has been the main barrier for the development of photovoltaics. Since 2018, there has been political certainty, which has led to a notable increase in installed capacity. Nevertheless, currently there are other types of barriers to the development of the PV industry, linked to lengthy and duplication of administrative processes, to auction designs for the development of renewables and the lack of PV professionals in the sector that has produced certain bottlenecks for the development of the industry.

On the other hand, the main drivers for the development of ground-mounted plants have been the use of PPA for long-term development, and the benefits that infra-marginal technologies have derived from the high spot market prices, thanks to the marginalist system.

Also, the increase in electricity prices due to the international price crisis, the war in Ukraine and inflation has led many companies and private consumers to install photovoltaic self-consumption systems. This has been boosted by government support, as noted above.

6.3 Interest from municipalities and local governments

Many municipalities are showing interest for creating energy communities. Energy communities are collective initiatives where individuals, households, or organizations come together to collectively generate, manage, and consume energy. They empower citizens to actively participate in the clean energy transition. Municipalities are interested in developing energy communities because they contribute to local energy resilience, reduce dependence on centralized energy systems, and create opportunities for local job creation. They also enhance public acceptance of renewable energy projects and make it easier to attract private investments. Moreover, they enable municipalities to meet their sustainability goals, engage their communities in decision-making processes, and empower citizens to shape their energy future.

Usually, local governments are in favour of PV developments, because they can notably increase their incomes via taxes, create jobs and mobilize the local economy. Nevertheless, we have seen barriers to PV projects there where developers miscommunicate and skip working together with local governments. If developers work in an extractivist manner, negative dynamics are generated that feed NIMBYs. Usually fostering communication between the local communities, local governments and developers helps in the development of projects.

Other barriers to develop PV from municipalities in Spain was the building permits. Building permits are administrative authorizations that used to be mandatory for residential self-consumption installations. These building permits for PV self-consumption are not mandatory anymore but many misinformed municipalities are still requesting them. For many industrial self-consumption installations building permits are required slowing down the installation of self-consumption PV.

7 HIGHLIGHTS AND PROSPECTS

7.1 Highlights

In 2022 Spain was the largest photovoltaic market in Europe and the fifth of the world in terms of annual installed capacity. Over 8.4 GWdc of new PV capacity was installed. The self-consumption segment increased by 108%, reaching 3 GWdc while 5,4 GWdc new capacity of ground-mounted plants was installed. The vast majority of this new capacity was introduced without any type of aid or regulatory remuneration scheme.

On the policy side, during the last few years Spain has undergone several regulatory changes. In 2020, Royal Decree-law 23/2020, introduced administrative milestones to develop power plants, RD 1183/2020 introduced a new access and connection framework, and RD 960/2020 introduced renewable auctions. These decrees established the regulatory framework for the development of renewables in our country in the coming years.

This changes in the energy sector were reinforced by Law 17/2021 on Climate Change and Energy Transition, which guides the decarbonization policies of all sectors of the economy. For the energy sector, the law establishes the National Integrated Energy and Climate Plan (NECP) as the planning tool that integrates energy and climate change mitigation policy. During 2023, the NECP energy target for 2030 will be updated following the new EU targets.

7.2 Prospects

Recently (June 2023) the Government presented a proposal to set the new renewable objectives for 2030. The 2030 target update, which is currently under consultation, indicates that the PV target will be increased from 39 GW (current target) to 76 GW, including 19 GW of self-consumption. It is expected that this will continue to boost photovoltaic energy in Spain in an extraordinary way, reaching the objectives set by the REPower EU Plan of the European Union.

Changes in the European energy market level are expected which will have a direct impact on the Spanish market. Market reforms are likely to come hand in hand with the strengthening of forward contracts such as PPAs, and changes in renewable auction designs. The State is also expected to play a more active role in ensuring that PPAs are more accessible. Specific measures on access to financing for actors opting for medium- and long-term contracts (as PPA) are also expected.

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