

International Energy Agency
Photovoltaic Power Systems Programme





National Survey Report of PV Power Applications in **FRANCE** 2022



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 TCPs 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 Copper 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.

Authors

- Main Content: Mélodie DE L'EPINE, Emilien LASSARA
- Data: ENEDIS, SDES, RTE
- Analysis: Mélodie DE L'EPINE

DISCLAIMER

The IEA PVPS TCP is organised under the auspices of the International Energy Agency (IEA) but is functionally and legally autonomous. Views, findings and publications of the IEA PVPS TCP do not necessarily represent the views or policies of the IEA Secretariat or its individual member countries.

COVER PICTURE

La Grange du Causse 12 MW system in Pézènes-les-Mines, Hérault, France by Boralex, with a 20 year Corporate Power Purchase Agreement. Image credits: BORALEX.



TABLE OF CONTENTS

Acknow	wledge	nents	. 5
MAIN	REFER	ENCES	. 5
1	Installa	ation Data	. 6
	1.1	Applications for Photovoltaics	. 6
	1.2	Total photovoltaic power installed	. 7
	1.3	Key enablers of PV development	. 12
2	Compe	etitiveness of PV electricity	. 12
	2.1	Module prices	. 13
	2.2	System prices	. 14
	2.3	Cost breakdown of PV installations	. 16
	2.4	Financial Parameters and specific financing programs	. 18
	2.5	Specific investments programs	. 18
	2.6	Merchant PV/PPA/CPPA	. 20
	2.7	Additional Country information	. 20
3	Policy	Framework	. 22
	3.1	National targets for PV	. 23
	3.2	Direct support policies for PV installations	. 23
	3.3	Self-consumption measures	. 26
	3.4	Collective self-consumption, community solar and similar measures	. 28
	3.5	Tenders, auctions & similar schemes	. 29
	3.6	Other utility-scale measures including, floating and agricultural PV	. 30
	3.7	Indirect policy issues	. 31
	3.8	Financing and cost of support measures	. 33
	3.9	Grid integration policies	. 33
4	Indust	у	. 36
	4.1	Production of ingots and wafers (crystalline silicon industry)	. 36
	4.2	Production of photovoltaic cells and modules	. 36
	4.3	Manufacturing Projects	. 38
	4.4	Manufacturers and suppliers of other components	. 38
5	PV In	The Economy	. 40



	5.1	Labour places	. 40
	5.2	Business value	. 40
6	Intere	st From Electricity Stakeholders	. 41
	6.1	Structure of the electricity system	. 41
	6.2	Interest from electricity utility businesses	. 42
	6.3	Interest from municipalities and local governments	. 42
7	Highli	ghts and Prospects	. 42
	7.1	Highlights	. 42
	7.2	Prospects	. 43



ACKNOWLEDGEMENTS

This paper received valuable contributions from different sources mentioned in the references, and in particular from Paul KAAIJK, ADEME Valbonne

MAIN REFERENCES

The principal references are cited below; however, a number of additional sources, including web sites, private communications and diverse publications were also used.

- "Tableau de bord photovoltaïque", St@tinfo, n° 527, February 2023 and n° 550 May 2023 (SDES — Service de la donnée et des études statistiques, Commissariat au Développement Durable, the Ministry for the Ecological and Inclusive Transition);
- Registre national des installations de production et de stockage d'électricité (National Register of Generators and electricity storage systems);
- "Bilans des Raccordements", Enedis Open Data (distribution grid manager for 95 % of the nation);
- "Bilan électrique 2022" (RTE Electricity Report 2022), RTE, February 2023 (Transport grid manager);
- "Baromètre décembre 2022", AVERE;
- "Coûts des énergies renouvelables et de récupération en France Edition 2022" ADEME;
- "Charges de service public de l'énergie prévisionnelles au titre de l'année 2023", CRE;
- "Suivi du marché 2021 des installations solaires photovoltaïques individuelles" Observ'ER July 2022
- "Marchés et emplois concourant à la transition énergétique" ADEME, September 2022
- "Une nouvelle ère énergétique" France Territoire Solaire, June 2022
- "Baromètre des achats d'énergie verte en France" T1 to T4 2022 Capgemini invent;
- Public reports on national Call for Tenders dedicated to solar energy, CRE (Rapport de synthèse (version publique), Appel d'offres portant sur la réalisation et l'exploitation d'installations de production d'électricité à partir de techniques de conversion du rayonnement solaire, Commission de Régulation de l'Energie) (several publications, 2021 and 2023);
- https://forum-photovoltaique.fr



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.

Data collection includes information on storage capacity, and the injection type is now collected by Enedis (total or partial self-consumption, full generation sales).

Official statistics report the AC power of photovoltaic fields, despite eligibility for Feed-in Tariffs and Tender support mechanisms being indicated in peak DC power thresholds. It may be useful for the reader to know that the average generation across France is 1 160 kWh/kW, but that systems installed in the southern half of mainland France will generate more, up to 1 550 kWh/kW, and in overseas territories up to and over 1 700 kWh/kWp. For the purposes of this report, all AC data has been converted to DC power, with a standard ratio of 1,2 (AC to DC) unless otherwise specified. In the particular segment of utility scale systems, some data is available on both DC and AC power and the reported DC power has been used.

Little data is available on off-grid applications as there are few support mechanisms that allow observers to track installation volumes.

1.1 Applications for Photovoltaics

The principal applications for photovoltaics in France in 2022 are grid connected:

- Residential (house and multi-apartment) systems. These systems tend to range from one or two modules with self-consumption through to standard 3 kW, 6 kW or 9 kW systems. Much of the current total capacity was installed during the 2009/2011" boom" and is building integrated – however, since 2017, new capacity is only building applied PV.
- **Commercial, agricultural or industrial** systems on buildings (36 kW to 250 kW AC or around 300 kW DC). A small proportion (3 % of total new capacity) are systems between 9 kW and 36 kW, generally on public buildings such as town halls, primary schools or technical services buildings.
- Industrial building mounted or parking canopy systems (250 kW to 10 MW)
- Utility scale ground mounted systems (over 10 MW)

Small but growing segments include agrivoltaics and floating PV.

A small amount of off grid systems has been installed in overseas territories (Guiana, etc.) or in mainland mountainous areas.

There was strong growth across residential segments and whilst the commercial and utility segments contracted from 2021, they still dominated newly installed capacity, with 50 % of newly installed power connected to the medium or high voltage grid, and residential systems accounting for less than 15 % of the total, despite nearly twice as many systems installed (by number) in 2022.



1.2 Total photovoltaic power installed

- **Centralised**: any PV installation which only injects electricity and is not associated with a consumer (no self-consumption) over 1 MW
- **Decentralised**: any PV installation which is embedded into a customer's premises (either with or without self-consumption) under 1 MW

Cumulative PV installed capacity as of the end of 2022 reached 16 330 MW (AC or inverter power) or roughly 20 GW DC (module power).

Data collection process

Data supplied by all transmission and distribution grid managers is aggregated and published by the SDES: Service de la Donnée et des Etudes Statistiques, Ministry for the Ecological and Inclusive Transition. Data is segmented by systems size (< 3 kW, < 9 kW, < 36 kW, < 100 kW, < 250 kW, above 250 kW). Data accuracy is an estimated 5 %. Data publication segments published by the major distribution grid operator (DSO), Enedis, were modified and now include segments for total self-consumption, partial self-consumption and feed-in systems.

Capacity data published by the SDES and in the national register is given as the AC power of system, whilst Enedis does not specify if the data is DC or AC, but it does tend to correspond to AC power, with an unknown of the capacity of total self-consumption systems. If the difference between the DC and AC reported powers in the past was not consequent, the divergence is now increasing, particularly considering the current world-wide trend to reduce the AC/DC (inverter to modules) ratio. See introductory notes on the conversion actors.

For the purposes of this report, we have considered the following hypotheses for data collected in 2022:

Grid connected distributed (decentralised) systems:

- **Residential**: up to 9 kW no data are available concerning the split BIPV/BAPV for new systems since 2017;
- **Commercial**: all systems 9 kW to 250 kW are Commercial BAPV (Building Applied Photovoltaics).

Grid connected centralised ground mounted systems:

- **Industrial**: all systems from 250 kW to 10 MW are Industrial or Ground-mounted. The split between Building-mounted and Ground-mounted is extrapolated from grid connection data published by Enedis;
- Utility scale systems: all systems over 10 MW and/or floating systems under 10 MW if known.

Off-grid PV power systems: There is no official data collection process for off-grid systems in France; any data presented are best-of-knowledge estimates.



Table 1: Annual PV power installed during calendar year 2022

	Installed PV capacity in 2022 [MW DC]
Decentralised	1 380
Centralised	1 586
Off-grid	
Total	2 966

SOURCE: SDES, Observ'ER, Enedis, *split is estimated BI France

Table 2: PV power installed during calendar year 2022

			Installed PV capacity [MW]	Installed PV capacity	Reported in AC
				[MW DC]	
Grid-	BAPV	Residential		407	339
connected		Commercial	2381	946	788
		Industrial		1028	857
	BIPV	Residential	No data available for 2022		
		Commercial			
		Industrial			
	Utility-	Ground-mounted		561	488
	scale	Floating	586	25	
		Agricultural			
Off-grid		Residential			
		Other	NA		
		Hybrid systems			
Total			296	6	

SOURCE: SDES, Observ'ER, Enedis, *some splits estimated BI France



Table 3: Data collection process

If data are reported in AC, please mention a conversion coefficient to estimate DC installations.	All power data is given in AC power. Conversion coefficient is 1.2. A majority of building applied PV with little evolution in practices on inverter/PV power ratios; some variability for ground-based systems with latitude (1.1 in north to 1.3 in south)
Is the collection process done by an official body or a private company/Association?	Data supplied by all transmission and distribution grid managers is aggregated and published by the Service de la donnée et des études statistiques, Commissariat au Développement Durable, the Ministry for the Ecological and Inclusive Transition. Enedis (national DSO) publishes segmented data. author has further segmented data as required.
Link to official statistics (if this exists)	https://www.statistiques.developpement-durable.gouv.fr/les- energies-renouvelables?rubrique=21
Data quality	Data is of good quality, however provisional, and may be revised as grid operators provide additional information. Some divergence in capacity volumes may exist depending on the segments represented; the error source may be related to reporting dates, provisional data and/or collection methods. Historical data may be in DC.



Year	Off-grid [MW] (including large hybrids)	Grid-connected distributed [MW] (BAPV, BIPV)	Grid-connected centralised [MW] (Ground, floating, agricultural)	Total [MW]
2008	22.9	180	8	211
2009	29.2	360	50	440
2010	29.3	1126	290	1445
2011	29.4	2690	842	3562
2012	29.6	3662	1214	4906
2013	29.7	4145	1517	5691
2014	29.75	4756	2051	6836
2015	30.15	5108	2782	7920
2016	30.15*	5488	3118	8635
2017	30.15*	5982	3701	9713
2018	30.15*	6410	4315	10 756
2019	30.15*	6955	4945	11 931
2020	30.15*	7571	5497	13 098
2021	30.15*	8873	7865	16 737*
2022		11 211	8388	19 600

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

*revised in 1st quarter 2023

Table 5: Other PV market information

	2022				
	Peak Power range	Installations (number)	Power [MW DC]		
	0 – 3 kW	423 072	1102		
	3 kW–9 kW	172 870	1022		
Number of DV systems in operation in	9 kW–36 kW	28 210	685		
your country	36 kW–100 kW	32 524	2796		
	100 kW–250 kW	9192	1707		
	> 250 kW	2671	9020		
	Total	668 539	16 333		
	Total Off-grid		30		



Decommissioned PV systems during the year [MW]	0 (estimated).
Repowered PV systems during the year [MW]	0 to 10 (estimated).
Unregistered capacity	Analysis of the data from the 3 major sources (SDES, Enedis and the Register). A reporting error by Enedis between Q4 2021 and Q2 2022 has made some interpretations uncertain.

Sources: SDES, Registre national des installations de production et de stockage d'électricité (2021), Open data réseaux énergies (ODRÉ) *Becquerel Institute France extrapolations. Data has been converted from reported AC to DC power, with a standard ratio of 1,2 and rounded.

Table 6: PV power and the broader national energy market

	2021	2022
Total power generation capacities [GW]	 Total: 139.07 GW of which Nuclear: 61.37 GW Fossil fuel: 17.9 GW RES: 59.8 GW (see below) 	 Total: 144.3 GW of which Nuclear: 61.37 GW Fossil fuel: 17.3 GW RES: 64.9 GW (see below)
Total renewable power generation capacities (including hydropower) [GW]	 PV*: 13.1 GW Hydro: 25.7 GW Wind: 18.8 GW Other RES: 2.2 GW 	 PV*: 15.7 GW Hydro: 25.9 GW Wind: 21.1 GW Other RES: 2.3 GW
Total electricity demand [TWh]	467	459
New power generation capacities installed [GW]	Total: 2.7 GW of which • Gas: +0.496 GW • Coal: - 1.16 GW • Diesel: 0.0 GW • Nuclear: 0 GW • PV and other RES: 3.9 GW (see below)	 Total: 5.6 GW of which Gas: +0.4 GW PV and other RES: 5.1 GW (see below)
New renewable power generation capacities (including hydropower) [GW]	 PV*: + 2.69 GW Wind: + 1.19 GW Hydro: + 0.00 GW Other RES: + 0.06 GW 	 PV*: + 2.6 GW Wind: + 2.4 GW Hydro: + 0.1 GW Other RES: 0 GW
Estimated total PV electricity production (including self- consumed PV electricity) in [GWh]	14 200	18 600
Total PV electricity production as a % of total electricity consumption	3 %	4,1 %



	1 160 kWh/kW (30° south facing fixed systems with system losses (PV GIS) – France mainland)
Average yield of PV installations (in kWh/kWp)	Ranges from 900 kWh/kW to 1 550 kWh/kW
	(30° with system losses (PV GIS) – continental France)

2021: RTE France Electricity Report 2021. 2022 RTE France Electricity Report 2022

*Data in this table is provided by RTE and provisional PV *are AC power only*.

** Source: SDES, non-energy uses included.

1.3 Key enablers of PV development

Table 7. Information on key enablers.	Table	7:	Information	on ke	ey enabl	ers.
---------------------------------------	-------	----	-------------	-------	----------	------

	Description	Annual Volume	Total Volume	Source
Decentralised storage systems	slight steepening of curve in T2 2022; data from CONSEUL (for year 2022) and ENEDIS for total. Total does not include DOM so is under reported	1417 systems*	9188 systems	CONSUEL annual report (electricity safety certification organisation) and ENEDIS number of storage systems
Residential Heat Pumps (number)	air/air + water/water + air/water	346 313 +2915 +772 324 = 1 121 552		Uniclim Bilan 2022
100 % Electric cars (number)		219 744	690 093	AVERE Baromètre dec 2022
Hybrid rechargeables (number)		127 110	412 882	AVERE Baromètre dec 2022

2 COMPETITIVENESS OF PV ELECTRICITY

The past two years were unprecedented for the competitiveness of photovoltaic electricity in France, as in much of Europe. Rising equipment costs due to follow on effects of COVID and economic growth (primary materials costs, supply chain disruptions, local and international growth markets) increased the cost of photovoltaic systems, with significant impacts on module cost through the first half of 2022, whilst steel and other costs were more stable. Module costs



dropped slightly in the second half, but with little impact on residential and commercial market segments. Photovoltaic remain an attractive source of electricity despite its concurrent, but lower, increased costs.

Data on market prices is published irregularly, based on either surveys or, when published by the Energy Regulation Commission, data provided by tender candidates. 2022 data are based on limited market surveys conducted for the purposes of this report, and due to the different factors disrupting the market, can only be used as a guide, with significant cost differences between early and late 2022, and even greater differences between prices quoted in 2022 for future systems, and prices paid in 2022 for systems reaching commissioning. The second half of 2022 saw prices stabilise to some extent, and module prices decreased in 2023.

2.1 Module prices

A 2019 study by the Energy Regulation Commission (CRE) provides the most recent largescale survey of price breakdowns in France. The business plans in the CRE study include the module prices that the candidates expect to pay. The lead-time between project submission to the tender and module acquisition is generally between 16 and 18 months. Module costs reported below are average costs according to the expected commissioning year and are differentiated according to the system size. This survey is still used as the basis for cost estimations and market reports by public and private organisations in France (including ADEME).

Table 8: Typical module prices

	Typical price of a standard module crystalline silicon			
Year	EUR/Wp			
	2020	2021	2022	
Average module price (all technologies)	0,35-0.4	0.25 - 0.4	0.25 - 0.4	

SOURCE: CRE "Coûts et rentabilités du grand photovoltaïque en métropole continentale", pvXchange and Hespul estimate. 2022 data from Becquerel Institute France limited market survey.



2.2 System prices

There is a wide range in turnkey prices, especially in the small to medium size segment. This range of prices is determined by the ease of installation (or the state of repair and complexity of the existing roof), the type of supporting structures needed, the complexity of the grid connection and the development time associated with these complexities. Through 2021 and into 2022, those companies working on residential and small-scale systems generally maintained costs with small positive changes despite the increased material costs.

Category/Size	Typical applications and brief details	Current prices [EUR/W]
Residential BAPV < 3 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. Equipment and labour.	2.3 – 2.5
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. Equipment and labour.	2.2 (1.2 – 3)
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.	2.0 - 3.5
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.	1.1 (0.8 - 1.3)
Large commercial BAPV 100-250 kW	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity to grid-connected large commercial buildings, such as public buildings, multi- family houses, agriculture barns, grocery stores etc.	0.7 - 0.9
Industrial BAPV >250 kW	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity to grid-connected industrial buildings, warehouses, etc.	0.8 - 1.1
Small, centralised PV 1-20 MW	Grid-connected, ground-mounted, centralised 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.	0.65 - 0.95
Other	Parking canopy centralised 10 MW - 20 MW	0.9 - 1.1

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

SOURCE: estimation Becquerel Institute France based on limited market surveys.



Year	Residential BAPV	Small commercial BAPV	Large commercial BAPV	Centralised PV
	Grid-connected, roof-mounted, distributed PV system 5-10 kW [EUR/W]	Grid-connected, roof-mounted, distributed PV systems 10-100 kW [EUR/W]	Grid-connected, roof-mounted, distributed PV systems 100-250 kW [EUR/W]	Grid-connected, ground-mounted, centralised PV systems 10-50 MW [EUR/W]
2007	8.4	7.8		6.3
2008	8.2	7.6		6.2
2009	6.9	6.4		5.2
2010	5.9	5.5		4.5
2011	3.9	2.6		2
2012	3.7	2		1.6
2013	2.7	2		1.3
2014	2.6	2		1.3
2015	2.5	1.9		1.2
2016	2.41	1.58		1.1
2017	2.2	1.2		0.9 - 1.1
2018	2.2	1.2		0.7 - 0.9
2019	2	1.2	1.2	0.65 - 0.85
2020	1.9	1.1	0.9	0.65 - 0.85
2021	1.7 – 2.5	0.6 – 1.7	0.7 – 1.1	0.5 - 0.9
2022	2.2 (1.2 – 3)	1.1 (0.8 – 1.3)	0.7 - 0.9	0.65 - 0.95

Table 10: National trends in system prices for different applications

NOTE — The table includes BIPV-IAB systems up to 3 kW until 2012, BIPV-IAB systems up to 9 kW from 2013 to 2016 and BAPV systems up to 9 kW since 2017.

SOURCE: Previous IEA NSR-FR reports, Observ'ER, limited market surveys by Hespul, Becquerel Institute France. VAT not included *IAB: completely building integrated; **ISB: simplified building integration; BAPV building applied/roof top systems.



2.3 Cost breakdown of PV installations

The Renewable Energy Trade Association (Syndicat des Energies Renouvelables, SER) study evaluating the contribution to renewable to the French economy, published in 2020, builds on the 2019 energy Regulation Commissions study on the cost of photovoltaics in France, with results as detailed below. This data is still used in national studies by private and public bodies as they are the most recent, comprehensive, publicly available studies. Limited market surveys have been used to evaluate the cost redistributions in the context of rising upstream costs as professionals responded to these events. Observ'ER conducts a yearly survey of professionals with partial cost breakdowns for systems under 3 kW. The survey of 2021 costs indicates that for smaller systems installation work is up to 0.57 EUR/Wp in early 2022, where this increase in installation costs billed by installers is to compensate for reduced margins on material and equipment.

In terms of operating costs (OPEX), extreme weather events in 2022 (hail, wind) led to numerous insurance claims from generators, with impacts on 2023 insurance costs and availability, as some insurances decide to reduce or stop taking on new clients or systems. In parallel, tension on the inverter market led to long lead times or searches for alternatives for replacement inverters in case of faults, also impacting operating costs.

Cost category	Average [EUR/W]	Low [EUR/W]	High [EUR/W]
н	lardware		
Module	0.65	0.4	1
Inverter	0.35	0.22	0.47
Mounting material	0.25	0.2	0.33
Other electronics (cables, etc.)	0.35	0.4	1
Subtotal Hardware	1.6		
S	oft costs		
Planning			
Installation work			
Shipping and travel expenses to customer	0.2		
Permits and commissioning (i.e. cost for electrician, etc.)			
Project margin			
Subtotal Soft costs	0.2		
Total (excluding VAT)	1.8		
Average VAT	0.2		
Total (including VAT)	2.2		

Table 11: Cost breakdown for a grid-connected roof-mounted, distributed residential PV system of 5-10 kW



SOURCE: "Évaluation et analyse de la contribution des énergies renouvelables à l'économie de la France et de ses territoires" SER/EY June 2021, market surveys (Hespul, Becquerel Institute France).

For this segment, module and inverter prices are well above that of other segments; in France both distributors and installers add a margin to module costs.

Cost category	Average [EUR/W]		
Module	0.27		
Inverter	0.06		
Mounting material	0.1		
Other electronics (cables, etc.)	0.11		
Subtotal Hardware	0.54		
Planning			
Installation work			
Shipping and travel expenses to customer	0.12		
Permits and commissioning (i.e., cost for electrician, etc.)			
Project margin			
Subtotal Soft costs	0.12		
Grid connection	0.08		
Total (excluding VAT)	0.74		
Average VAT	20 %		
Total (including VAT)	0.88		

Table 12: Cost breakdown for a grid-connected, ground-mounted, centralised PV systems of >10 MW $\,$

SOURCE: "Évaluation et analyse de la contribution des énergies renouvelables à l'économie de la France et de ses territoires" SER/EY June 2021, Estimations by Hespul, Becquerel Institute France



2.4 Financial Parameters and specific financing programs

 Table 13: PV financing information in 2022

Different market segments	Loan rate [%]
Average rate of loans – residential installations	6 % - 9 % over 12 years, 1 % to 2 % increase since 2021
Average rate of loans – commercial installations	From 1.6 % (January) to 3.5 % (December) for 12 to 18 years
Average cost of capital – industrial and ground-mounted installations	3 to 4 % over 20 years

SOURCE: ADEME study "Coûts des énergies renouvelables et de récupération en France" 2022, CRE "Coûts et rentabilités du grand photovoltaïque en métropole continentale", Statinfo Crédit aux particuliers and Crédit au SNF, Taux des crédits aux entreprises by Banque de France, estimation Becquerel Institute France, Hespul.

* Rate of loans for residential applications are considered consumer credit which explains their relatively high level, well above home loans.

Interest rates for all sectors increased through 2022 with significant rises from March at the start of the Ukraine war, resulting in rates roughly three times those of late 2021. Impacts on projects in late planning stages were significant as commercial and industrial projects that had not reached financial close became unviable with the near overnight rise in interest rates.

2.5 Specific investments programs

Table 14: Summary of existing investment schemes

Investment Schemes	Introduced in France
Third party ownership (no investment)	Used for commercial and industrial systems (roof and land rental), but also to a lesser extent on new agricultural buildings.
Renting	A few small-scale operations in self-consumption models where building occupiers rent PV systems. This is a growth segment with continued high interest in 2022.
Leasing	Leasing is a common financing instrument in France for commercial systems. "Sofergie" (Energy Financing Company) provide credit or leasing options for projects developed by municipalities, social housing organisations, commercial companies and agricultural companies.
Financing through utilities	Some electric utilities (more often their subsidiaries) develop and invest in PV systems, but they do not offer finance for third parties. Utilities can access all support mechanisms, including FiT and Tenders for systems that they develop or own.



Investment in PV plants against free electricity	(See self-consumption).				
Crowd funding (investment in PV	Crowdfunding generally finances debt through crowd-funding platforms, however some platforms allow for equity financing.				
plants)	Changes to the bonus mechanisms in the new PPE2 Tenders have resulted in a significant shift from citizen investment and governance debt crowdfunding.				
Community solar	Yes				
International organization financing	No				

The main financing organizations are commercial banks (both French and foreign), debt funds (French and foreign insurers) and institutional lenders (European and national).

Cleantech investments in France dropped slightly in 2022, including for the renewables sector (down to 495 million euros total investment from 2021's 595 million euros). The largest operation in the RES sector was Voltalia, with 395 million euros raised from a single investor (for a total of 490 million in the operation).

Portfolio financing

Portfolio financing/refinancing and large or utility-scale projects can make use of the European Investment Bank (European long-term investment fund—EIB) offers.

The EIB supports a number of renewable energy source (RES) investments funds available for photovoltaics projects. The EIB approved a number of credit lines to local financing organisations within different mechanisms including new amounts for the CALEF - PAN-EUROPEAN RENEWABLE ENERGY FL (Crédit Agricole) SG PAN-EUROPEAN RENEWABLE ENERGY FL (Societé Générale) and CEPAC ACTION POUR LE CLIMAT FL (Caisse d'Epargne) loans (respectively 500 million euros, 400 million euros and 350 million euros for small to medium projects).

Other major actors include La Banque des Territoires (Caisse des Dépôts) and its subsidiary Bpifrance.

Project financing

Project financing, classically used for infrastructure projects, is based on project cash flows repaying project debt and equity. Project financing for privately owned projects is available through both commercial banks and bpifrance, a public investment bank. Public authorities can access financing from public long-term investors such as the Caisse des Dépôts (Deposits and Consignments Fund).

Project financing is also available through Sofergies - financial companies that provide debt financing or leasing options for energy efficiency and renewable energy projects by



municipalities, social housing organisation, commercial companies and agricultural companies.

Bpifrance has increased volumes available for project financing as part of its 2021-2024, building on its regional presence to identify local requirements. Examples of project financing include ETIC Partners 4.7 million euros for 150 farms roofs.

Community solar (citizen investment)

Citizen investment is mobilised through specific citizen RES funds and crowdfunding platforms - financing both equity and debt. The principal organisations active in channelling citizen investment are crowdfunding platforms (debt and equity investments) and Energie Partagée. In 2022, Energy Partagée acquired the remaining participations in EnRciT from its initial institutional investors and collected 0.9 million euros in 2022.

15 new solar community projects for 3,2 MW were commissioned in 2022, bringing the total since inception up to 81.5 MW, representing 17,6 million euros in direct community investment for systems ranging from small 9 kW projects to multi-MW ground-based systems.

Residential project financing

Residential systems are financed through different schemes: 100 % owner capital, home renovation loans or consumer credit loans.

2.6 Merchant PV/PPA/CPPA

There is a small but growing corporate power purchase agreement (CPPA) market in France, with 10 major developers having signed with major companies such as SNCF (national railways), airports, and international corporations (Amazon etc). In 2022, seven CPPA greenfield projects were announced, with commissioning planned from 2024 to 2027. 4th quarter announcements total a planned 790 GWh/year from 2026/2027.

Contracts for greenfield systems run from 15 to 25 years, with an occasional contract announced for only 10 years. For systems moving away from feed in contracts, contracts tend to a 3-to-5-year limit.

2.7 Additional Country information

Retail electricity prices for a household	 Time of use contracts available. Eurostat Band DC (2 500 kWh < consumption < 5 000 kWh) 220.4 EUR/MWh all taxes and levies included.
Retail electricity prices for a commercial company	 Time of use contracts available. Eurostat Band IB (20 MWh < consumption < 500 MWh): 147 EUR/MWh excluding VAT and other recoverable taxes and levies
Retail electricity prices for an industrial company	Time of use, demand response, peak shaving contracts available.



	Eurostat Band ID (2 000 MWh < consumption < 20 000 MWh):
	114.2 EUR/MWh excluding VAT and other recoverable taxes and levies
Liberalization of the electricity sector	France's electricity industry is highly concentrated but not vertically integrated in theory. However, in practice, EDF, is 100% state owned and its different wholly or partially owned subsidiary companies are the principal generator (over 80 % of electricity production), transport grid manager (100 %), distribution grid manager (over 95 % of grid subscribers) and retailer (over 75 % of retail customers).

SOURCE: INSEE, CRE, Eurostat [nrg_pc_204] and (nrg_pc_205) 2022S2.



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.

Category	Resid	lential	Commercial + Industrial		Centralised	
Measures in 2022	On-going	New	On-going	New	On-going	New
Feed-in tariffs	yes	Yes (changes to Feed in Tariff conditions)	yes	-	-	-
Feed-in premium (above market price)		-	Yes, (Contract for Difference in competitive Tenders)	Changes to Tender conditions	Yes, (Contract for Difference in competitive Tenders))	Changes to Tender conditions
Capital subsidies		-		-	-	-
Green certificates		-		-		
Renewable portfolio standards with/without PV requirements		-		-	-	-
Income tax credits		-		-	-	-
Self-consumption	yes	-	yes	-	-	-
Net-metering		-		-	-	-
Net-billing	yes	Yes (changes to Feed in Tariff conditions)	Yes (Feed in Tariffs up to 500 kW)	Yes (changes to Feed in Tariff conditions)	-	-
Collective self-consumption and delocalized net-metering	yes	-	yes	-	-	-
Sustainable building requirements		-		yes	-	-
BIPV incentives	Yes (bonus on	-	Yes (bonus on	-	-	-

Table 15: Summary of PV support measures



	Feed in	Feed in		
	Tariffs)	Tariffs up to		
		500 kW)		
Merchant PV facilitating measures			yes	

3.1 National targets for PV

The framework for developing photovoltaics policies in France falls within the long term National Low Carbon Strategy (SNBC, 2050 horizon) and the 10-year Energy Programme Decree (PPE). The current PPE, published in 2020, targets 3 GW to 5 GW a year new capacity, to reach 20 GW in 2023 and 35 GW to 44 GW in 2028. The PPE authorizes competitive tenders as the preferred mechanism to reach these goals if market forces are insufficient.

The government has signalled a real desire to meet the PPE targets, publishing an Action Plan to accelerate the development of photovoltaics in November 2021. This plan includes a possible feed in tariff for ground-based systems under 500 kW on wasteland (unpublished as of 2023), 1 000 projects on public land and buildings, a reduction in upfront grid connection costs and simplifications to administrative procedures.

The national environmental agency, ADEME, the national Transport network operator and the independent organisation négaWatt all published possible future energy scenarios in 2050, and all scenarios had a common element of high photovoltaics volumes needed in France by 2050, with volume ranging from 90 GW to nearly 200 GW – an indication of the accepted level of investment required from both the public and private sectors.

3.2 Direct support policies for PV installations

3.2.1 Open volume feed-in tariffs for BAPV

Feed-in tariffs and net-billing tariffs are segmented according to system size and decrease each trimester, with the decrease pegged to grid connection requests for previous trimesters. For overseas regions, the tariffs are adapted to regional irradiation levels. Tables 17 and 18 detail 4th quarter 2022 tariff levels.

Feed-in tariffs and net-billing tariffs are segmented according to system size and decrease each trimester, with the decrease pegged to grid connection requests for previous trimesters. For overseas regions, the tariffs are adapted to regional irradiation levels. Tables below detail 4 th quarter 2021 tariff levels.

The October 2021 framework, (modified July 2022) for feed in tariffs for systems up to 500 kW on buildings, greenhouses and parking canopies includes differentiated tariffs depending on system size and lump sums for smaller self-consumption systems (with net-billing) as well as specific building integrated products. Systems can first sell generation to collective self-consumption projects. Tarif reductions were frozen over late 2022/early 2023 and new inflation indexing was introduced. Mandatory 550 kg CO_2/kW maximum carbon footprint for modules in systems between 100 kW and 500 kW.



Tariff category	Power of PV installation	Tariff Q4 2022* (EUR/MWh)
Continental France — build	ding applied PV	
Ta (no self-consumption)	≤3 kW	224.2
Ta (no self-consumption)	3 kW to 9 kW	171.8
Tb (no self-consumption)	9 kW to 36 kW	136.5
Tb (no self-consumption)	36 kW to 100 kW	118.7
Tc (with or without self - consumption)	100 kW to 500 kW	128,8 x inflation coefficient

Table 16 — Feed-in Tariff and Tender remuneration levels – Mainland France

* For projects that will be built in 2023 or first semester 2024.

Table 17: Feed-in Tariff and Tender remuneration levels – Overseas France

Tariff category	Power of PV installation	Tariff Q4 2022 (EUR/MWh)
Sample system in Guadeloupe	2 kW	205.3
Sample system in Corsica	8 kW	161.1
Sample system in Réunion	50 kW	143.3

Note: for exact tariffs, refer to CRE publications; there is also a time-based compensation for grid manager commanded disconnections.

3.2.2 Feed-in tariffs and Feed-in premiums in competitive tenders

Volume capped periodic competitive tenders for systems from 500 kW to 30 MW (no size limit for ground-based systems on waste land) are segmented according to size and application (building applications, ground based etc.).

There were 8 national call for tenders in mainland France over 2022, including a technology neutral tender, but no tenders in the overseas territories.

The 2022 mainland tenders were all largely under-subscribed. The sustained rise in electricity prices across 2021 and 2022 and the interest for greenfield PPA's from corporate and enterprise led to this change as no subsidy is needed in most cases – hence the tenders, with all their conditions and constraints, are not particularly attractive.

3.2.3 BIPV development measures

The feed in tariff framework published in October 2021 includes an investment bonus for systems up to 500 kW using one of 4 approved, certified BIPV products. To be paid in 5 yearly instalments, the investment bonus is available for a maximum of 145 MW of projects over 2 years (30 MW in 2022, 115 MW in 2023) on a first come first served basis. The bonus can by combined with the partial self-consumption bonus and feed in tariffs/net billing.



System size	Bonus for grid connection request in the first period from 09/10/2021 au 08/10/2022, capped at 30 MW	Bonus for grid connection request in the second period from 09/10/2022 au 08/10/2023, capped at 115 MW
< 100 kW	0.238 EUR per W installed	0.133 EUR per W installed
100 kW to 250 kW	0.235 EUR per W installed	0.128 EUR per W installed
250 kW to 500 kW	0.233 EUR per W installed	0.125 EUR per W installed

Table 18 — Feed-in Tariff BIPV bonus – Mainland France

A number of indirect measures included mandatory solar or living roofs for commercial and industrial buildings or covered car parks occupying $\geq 500 \text{ m}^2$ of ground surface.

Actual thermal regulations, and incentive high-performance building labels encourage photovoltaics and self-consumption as electricity consumed and exported from the building can be integrated in building performance calculations.

3.2.4 Merchant PV development measures

Corporate PPA's are increasingly attractive considering rising electricity prices and consumer awareness, however securing financing has meant that only major and financially extremely stable companies are able to buy in as off takers so far. Petitions from industry and alternative suppliers and a national working group led to the announcement of a guarantee fund carried by bpifrance from 2023 that would ease the difficulty of obtaining financing for greenfield systems selling in CPPA, operating as a type of insurance in case of an off takers defaulting, however some sectors remain critical as it will not be available for small to medium buyers, or alternative electricity suppliers, essentially restricting the use to companies already in the market.



3.3 Self-consumption measures

Table 19: Summary of self-consumption regulations for small private PV systems in 2022

PV self- consumption	Right to self- consume	Individual self-consumption: the PV generator can be the consumer or a third-party owner. Participation in a collective self-consumption operation is limited to 3 use cases (see below): Virtual net-metering (virtual battery storage): the consumer must be the PV generator.		
	Revenues from self-consumed PV	Lump-sum for partial self-consumption systems in association with net-billing FiT. Winning candidates in the Self-Consumption Tender (systems from 500 kW to 10 MW) will receive a bonus on self-consumption at the tendered rate. Self-consumed electricity is not subject to tax for individual self-consumption. However, collective self-consumption is subject to tax. For individual self-consumption and in case of partial self- consumption, installed capacity is subject to capacity taxes, such as grid taxes		
	Charges to finance Transmission, Distribution grids & Renewable Levies	Systems with total self-consumption pay no connection or annual grid access costs. Systems in collective self-consumption systems pay grid connection costs and annual access fees.		
Excess PV electricity	Revenues from excess PV electricity injected into the grid	Net-billing set by FiT (Q4 2022: 75.2, 125.3 or 122,8 x coeff EUR/MWh depending on system size), or by Tender specifications (FiT or wholesale market + premium) or by PPA (Power Purchase Agreement). Systems may sell into collective self-consumption before selling excess within FIT framework.		
	Maximum timeframe for compensation of fluxes	Metering timeslots are 30 minutes.		
	Geographical compensation (virtual self- consumption or metering, use of the public or private grid)	 Called "collective self-consumption" in France. Participation in a collective self-consumption operation is limited to 3 use cases: 1. Default case: PV installations and consumers located in the same building. This opens the possibility for the participation of medium voltage connected PV installations; 2. Extended case: PV installations and consumers connected to the low voltage grid within a distance of 2 km of each other: 3. Exceptional case: PV installations and consumers within a distance of 20 km where the low population 		



		and building density requires an exceptionally large perimeter.
		In all cases, generators(s) and consumers(s) must be linked through a common legal entity. Compensation on a 30-minute time-step.
	Number of participants (individual or collective self- consumption)	Individual self-consumption limited to 1 participant. No limit in participant numbers for collective self- consumption, but there are generator capacity limits
Other characteristics	Regulatory scheme duration	20 years for surplus (net-billing) sold in FiT, 10 years in Self- Consumption Tender. Collective self-consumption determined by private contract.
	Third party ownership accepted	Third party ownership is allowed but can be complex to manage.
	Grid codes and/or additional taxes/fees impacting the revenues of the prosumer	Grid connection fees for systems over 36 kVA. No grid access fees for total self-consumption systems. Reduced grid access fees for partial self-consumption systems (with net-billing). Energy taxes will apply in the case of collective self- consumption but not for individual self-consumption, even if the PV system is owned by a third-party.
	Regulations on enablers of self- consumption (storage, DSM)	Electricity storage is considered as both a consumer and a generator when integrated into collective self-consumption.
	PV system size limitations	Automatic grid connection limited to systems < 36 kVA with no surplus injections and no grid fees—other systems require approval. Systems limited to 500 kW on buildings for access to net- billing and lump-sum within FiT framework. Systems must be between 500 kW to 10 MW to access Tenders (it is possible in this context to have a generator sell directly to a consumer without the generator being a registered electricity supplier). In the case of "extended" collective self-consumption projects, the total PV volume is limited to 3 MW mainland and to 0.5 MW (power is expressed in peak DC power) in non- interconnected territories.
	Electricity system limitations	Mainland, no limits. In overseas territories (ZNI), self-consumption systems must respect the same capacity and disconnect limits as feed-in systems (i.e. active capacity must not go over 30 % (or as specified in the regional energy planning decree) of



	consumption (with the objective of raising this threshold to 45 % by 2023), grid manager disconnects on a first installed-last disconnected priority order).
Additional features	Markets sales of surplus in the framework of Tenders require access to an Aggregator/Balancing Responsible Party.
	Collective self-consumption systems can now access FiT for excess production sales since October 2021.
	Several virtual battery storage offers are available.

3.3.1 Net-billing feed-in tariff and lump sum for BAPV systems under 500 kW

Tariff category	Power of PV installation	Net-billing tariff (+ lump sum) Q4 2022 (EUR/MWh)
Continental France — building ap	plied PV	
Pa (net-billing)	≤3 kW	125.3 (+0.48 EUR/W installed)
Pa (net-billing)	3 kW to 9 kW	125.3 (+ 0.36 EUR/W installed)
Pb (net-billing)	9 kW to 36 kW	75.2 (+ 0.20 EUR/W installed)
Pb (net-billing)	36 kW to 100 kW	75.2 (+ 0.10 EUR/W installed)
Tc (net-billing)	100 kW to 500 kW	122.8 x inflation coefficient (no lump sum)

Table 20: Net billing Feed-in Tariffs for BAPV systems

3.3.2 Net-billing with feed-in premium

Winning candidates in Self-Consumption Tender (systems from 500 kW to 10 MW) receive a bonus on self-consumption at the tendered rate plus net-billing set by tender specifications (wholesale market + premium).

3.4 Collective self-consumption, community solar and similar measures

Consumption within a building, a 2 km, or exceptionally, a 20 km geographical perimeter. Where generators and consumers are in the same building, the PV installation can be connected to the medium voltage grid. In other cases, installations are connected to the low voltage grid and are limited to a total of 3 MW. Virtual metering is implemented by the grid manager and requires smart meters on all generation and consumption sites. Each operation must have a legal entity, whose primary role is to supply the grid manager with algorithms or rules defining the distribution of the PV power, and an updated list of registered members of the operation.



By the end of 2022, with a total of 8.3 MW (+ 4.5 MW since Q4 2021) across 149 projects, 1730 consumers and 280 generators were involved, with most indicators roughly doubling over 2022.

Economic models for self-consumption systems remain uncertain in the long term, as the competitivity of the self-consumed electricity is very dependent on consumer electricity costs. In other words, grid parity is reached in certain sectors, and not in others, despite the high consumption costs over 2022.

3.4.1 Solar Community

Solar communities (or citizen investment) continue to grow, with a specialised fund and regional and national networks supporting the inception and development of projects.

Work is on-going for the creation of the legal framework for citizen and renewable energy communities in France, but much awaited texts still remain to be published.

3.5 Tenders, auctions & similar schemes.

The energy minister establishes the Tender specifications, the CRE (Energy Regulator) manages the Tenders and transmits a list and analysis of the highest-ranking candidates to the Minister, who then determines and publishes the winning candidates.

Since 2016, the winners of the calls for tenders are no longer supported by a feed-in - tariff but by a contract for difference mechanism (CfD). With the CfD, the generators of photovoltaic electricity sell their production on the market, and when the reference market costs are under the tendered costs they receive additional remuneration from the state which compensates for the difference between the market price and the tendered cost. Conversely, when the reference market costs are above the tendered costs, operators are required to pay the difference back to the state.

With the unprecedented rise in market costs in late 2021, the prices on the electricity market have become much higher than the tendered prices. As a result, whilst the generators concerned have seen their revenues increase from their sales on the market, a significant portion of this revenues is paid to the state under the CfD mechanism. Not only does the French state not subsidise these contracts for those months, but it also receives a portion of the revenues generated by photovoltaics.

The CRE publishes a summary analysis after Tenders are awarded, making available aggregated and comparative information on the provenance of materials, average bids, etc.

The current framework (called PPE2) has selection criteria on a lowest price basis for commercial and self-consumption systems, but price weighted with additional environmental or land use criteria (low module carbon footprints and degraded anthropised sites are benefited), or even innovation levels, for larger systems.

The Energy Minister establishes the Tender specifications, the CRE (Energy Regulator) manages the Tenders and transmits a list and analysis of the highest-ranking candidates to the Minister, who then determines and publishes the winning candidates. Remuneration (through Feed-in PPA, Feed-in premiums, bonuses etc.) is paid to operators by EDF (or, in certain areas, local public distribution grid managers, or other authorised organisations).

There were 8 national call for tenders in mainland France over 2022, including a technology neutral tender, but no tenders in the overseas territories.



The 2022 mainland tenders were all largely under-subscribed. The sustained rise in electricity prices across 2021 and 2022 and the interest for greenfield PPA's from corporate and enterprise led to this, meaning no subsidy is needed in most cases, meaning the tenders, with all their conditions and constraints, are not particularly attractive.

3.5.1 Competitive tenders

System type and size	Building mounted systems, greenhouses and parking canopies	Ground-based systems and parking canopies	Building mounted systems for self- consumption	Technology neutral
Individual system size limits	From 0.5 MW No upper limit	0,5 MW to 30 MW No upper limit on degraded sites	0,5 MW to 10 MW	
Volume	4.2 GW to 5.6 GW in 14 calls of 300 MW to 400 MW	9.25 GW in 10 calls of 925 MW	0,7 GW in 14 calls of 50 MW	2,5 GW in 5 calls of 500 MW
Number of Bids	3 rd call: 89 MW selected for 155 MW of bids for 400 MW called	3 rd call: 115 MW selected of 485 MW of bids for 925 MW called	3 rd call: 10 MW selected for 24 MW of bids for 50 M called	1 st call: 180 MW selected for 226 MW of bids for 500 MW called
Average tendered price (or bonus for self- consumption)	3 rd call: 90.91 EUR/MWh	3 rd call: 82.23 EUR/MWh (40 % higher than 1 st call)	3 rd call: 10.7 EUR/MWh	1 st call: 73.5 EUR/MWh

Table 21: PPE2 (2021-2026) competitive tender volumes and results

All systems are remunerated through CfD = Contract for difference = Market sales + Additional Remuneration; Contract at tendered rate.

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

These systems are financed through competitive tenders, generally in a specific call for innovative systems.

The national Agency for Ecological Transition (ADEME) commissioned a study to define agrivoltaics (or agriphotovoltaics/agriPV), with a wide participation across the industry and the agricultural sectors in 2021, published in mid-2022 after extensive high-level discussion.



The tenders for systems on buildings was extended to include agrivoltaic canopies as well as greenhouses, although no systems of this type were selected in the last call (54 MW of greenhouses and 12.8 MW of agrivoltaic canopies submitted, 0 MW selected because of procedural errors.

Agrivoltaic and floating systems were developed and commissioned in 2022, financed through the Innovation competitive tenders.

3.7 Indirect policy issues

3.7.1 Rural electrification measures

Rural electrification in France is primarily concentrated in overseas territories and isolated alpine areas. Overseas territories include remote or difficult to access zones with small villages with either no mini-grid or fossil fuel powered mini-grids, particularly in French Guiana and the island of Reunion. The national budget includes a line dedicated to off grid production in rural areas, with a 1 MEUR budget in 202, equivalent to the 2021 and 2020 budget. In parallel, budgets are available for indirect measures such as electric vehicle charging points, partially financing grid connection in weak networks for renewable energies, storage and other innovations.

3.7.2 Support for electricity storage and demand response measures

There are no universal support mechanisms for electricity storage in France. However, public demand has seen a slow development in both the residential and commercial sectors, despite the low economic returns.

Large scale storage

In mainland France, by the end of 2022 about 235 storage facilities are connected to the medium-voltage grid with a capacity of 303 MW. 50 % of the cumulated installed capacity was commissioned in 2022. According to the National Registry for Generators and Storage, only seven (12 % in capacity) of these storage facilities are listed as being associated with photovoltaic systems connected to the medium voltage grid.

Individual/small scale storage

Conditions are not favourable for the development of small-scale storage in France (no subsidies, previously relatively low electricity consumption costs and winter peak consumption profiles on mainland France). There are about 13 000 (+1 400 mainland, + 720 overseas territories) storage facilities in France (9 200 on the mainland) on residential or small-scale installations. After a peak of 2 500 new installations per year in 2018 and 2019, the rate of installation continued to decrease through 2020 and 2021, with a slight rise in 2022 (up to approx. 1 400) on the mainland and a mor significant +34 % in overseas territories, with most of the new capacity on the Reunion Isles.

Demand Response Measures

Time-of-use electricity rates are offered to consumers in France, with a particular emphasis on displacing winter peak consumption to late night/early morning. France has very high winter evening peak demand, reflecting the high penetration of resistive electric heating.

Demand response mechanisms (flexibility) include both reduction and increases in consumption to respond to specific conditions – either through equipment shutdown or storage; given the habitual consumption profile and nuclear generation capacity in France, most is for



reducing demand. Projects offering less than 1 MW of flexibility must be aggregated with other projects, but projects offering over 1 MW can be certified individually.

Over winter 2022/2023 France's electricity supply was particularly constrained because of a number of nuclear power stations being offline for maintenance and very dry weather conditions impacting hydro-electricity generation. The government ran a national campaign inciting user, commercial, industrial and residential, to reduce their consumption or move its timing to prevent brown outs. This campaign was successful (extremely high electricity prices were surely an additional motivation), with a reduction of 1.7 % despite strong economic growth compared to previous years that were impacted by COVID – 2022 consumption rewound to 2005 levels, with most of the reduction coming from Q4, with consumption down about 9 % for November compared to pre-COVID levels.

On a more local level, ENEDIS ran a tender for small scale flexibility (up to several MW on a 30 minute or hourly time step) in 3 small geographical regions including 3 arrondissements in Paris but with mixed success (no submissions for one of the regions).

Enedis also runs an experimental project called REFLEX in two regions in France aiming to use flexibility mechanisms to release added grid capacity for renewables without infrastructure investments.

3.7.3 CPPA/PPA market

There is a small but growing corporate PPA market in France, mostly lead by major companies such as SNCF (national railways), airports, and international corporations (Amazon etc). In 2022, seven CPPA greenfield projects were announced, with commissioning planned from 2024 to 2027. 4th quarter announcements total a planned 790 GWh/year from 2026/2027. Contracts for greenfield systems run from 15 to 25 years, with an occasional contract announced for only 10 years. For systems moving away from feed in contracts, contracts tend to a 3-to-5-year limit. Corporate PPA's are increasingly attractive considering rising electricity prices and consumer awareness, however securing financing has meant that only major and financially extremely stable companies are able to buy in so far. Petitions from industry and alternative suppliers and a national working group led to the announcement of a guarantee fund that would ease the difficulty of obtaining financing for greenfield systems selling in CPPA. However some sectors remain critical as it will not be available for small to medium buyers, or alternative electricity suppliers, essentially restricting the use to companies already in the market.

3.7.4 Support for encouraging social acceptance of PV systems.

On a general level, solar enjoys a good level of social acceptance and approval level – 73 % trust the technology, but the decreasing trends continues (-3 % over 1 year). More significantly, the perception of renewables as environmentally friendly has dropped significantly over 2021/2022, down 7 points to 79 %. Despite this, with rising electricity costs, an April 2022 poll indicated intentions to buy solar were up 19 % year on year. The most significant change in support for any energy concerns nuclear, that gained 14 points of support from 2019, up to 60 %.

Social acceptance for utility scale projects in France has become a growing problem over the past years. Over 2022, media reports on opposition to utility scale projects (from 15 hectares up to several hundred) report that reasons range from the visual aspects to opposition to reducing tree cover, impacts on tourism-based economic activities to the cash flows to non-local companies. Representative organisations have produced fact checking documents to



combat the increasing appearance of disinformation or controversial claims concerning solar. Through 2021 and 2022, industry worked on gathering information on the environmental impacts of utility scale systems, resulting in several publications and a preliminary study commissioned by ADEME for setting up a "renewables and biodiversity resource centre", whilst the government has supported the development of citizen investment as a tool to increase social acceptance.

3.8 Financing and cost of support measures

Operator remuneration (through Feed-in tariffs, Additional remuneration —market premium, bonuses etc.) is paid to operators by a designated Co-contractor (EDF, other authorised organisations or, in certain areas, local public distribution grid managers). The Co-contractor is compensated for over-costs from a dedicated account in the national Budget (Energy Transition). This account is financed by a tax on petrol and its derivatives when used as an energy source for transport or heating.

Over-costs are calculated based on a typical production curve weighting of monthly average day time spot prices on the national electricity market. The estimated total cost of compensation for 2022 for photovoltaic contracts (Feed-in tariffs and premiums) for continental France is negative 724 M EUR, in other words a source of revenue for the state government.

3.9 Grid integration policies

3.9.1 Grid connection policies

In France grid connection costs are paid by generators, with total costs shared between an initial upfront payment by the generator directly proportional to costs and an annual access fees (TURPE).

The cost to the generator depends on:

- the works needed to connect the system to the grid, determined by the DSO and based on the existing grid capacity and infrastructure and the projects and works already in the grid connection queue;
- the cost of these works part of these costs are based on a pre-established framework and part depends on the specific system and site and they cover modifications needed upstream on the grid;
- the distribution of costs between the generator and the DSO; this distribution depends on the nominal voltage of the grid connection.

Costs can be mutualised if several systems are grouped together and connected in the same time frame.

Connections to the medium voltage grid and impacts on the medium and high voltage grid include contributions to regional funds (Schéma Régional de Raccordement au Réseau des Energies Renouvelables (S3REnR)) that finance future grid upgrades that are planned according to projected renewables growth, allowing for mutualised contributions to infrastructure costs such as high voltage grid upgrades, new substations etc. The regional contribution is payable for systems connected at 250 kVa and up, and ranges from 0 to roughly 80 000 EUR/MW depending on the regions current grid capacity and infrastructure and projected growth of decentralised generation.

The upfront costs can be significant, affecting project feasibility at all power levels, from residential systems to utility scale ground-based systems. These costs and the cost sharing



framework between generators and DSO is a recurring source of conflict with calls for more transparency on methods but also more agility in adjusting the S3REnR considering growth in renewables.

In the past single phase grid connection costs for small residential systems were a real barrier to the development of the sector, however the shift to self-consumption, with its mostly zero-fee grid connection, has both lowered the overall cost of residential systems and accelerated the grid connection times. It is unlikely that grid connection capacity will be a barrier for increased development of small residential systems.

Currently, the cost of grid connection for small commercial systems up to about 1 MW is extremely variable and difficult for installers and building owners to predict, which means that grid connection studies and quotes must be made before generators or investors can validate business plans – mechanically adding months to project planning. High costs are generally the direct consequence of older grid infrastructure or saturated substations, requiring the generator to assume the costs of infrastructure upgrades often benefitting both the generator but also consumers. The unpredictability of grid connection costs is a factor in the longer lead times for commissioning in France, and the abandon rate for projects across this segment. DSO efforts to improve visibility on grid connection costs in planning phases include establish grid capacity maps and automated web services to indicate the complexity of grid connection. Whilst these services do not supply all information, they are providing a first level of service that facilitates project planning.

Delays for grid connection are variable – from none for residential self-consumption systems up to a dozen years if TSO infrastructure is inadequate for a utility scale project. As a general rule, delays for most residential and commercial systems on the low voltage grid have delays from 3 months to about 18 months, whilst delays for connection to the medium voltage grid are dependent on local grid capacity and project works.

A wide ranging consultation with industry through early 2022 instigated cooperative talks on the possibility of modifying the "first in first served" principal regarding capacity reservations as, increasingly, small projects wanting to connect to the low voltage grid are being frozen out as larger projects immobilise all remaining capacity despite not being able to use the available capacity until upgrades on the medium or high voltage grid can be planned, often requiring several years to be completed.

With its strongly interlinked network, grid capacity in itself should not be a substantial barrier to the developments of photovoltaics per se, however aging rural infrastructure and the cost sharing model – with its impact on project viability - are not negligeable barriers, and the long lead time for increasing transport network capacity means that France's ambitious development goals may not be that easy to reach. A variety of experimental projects testing methods to increase grid connection capacity either whilst waiting for infrastructure upgrades or to avoid them altogether are underway, including dynamic curtailment and other management policies. In parallel, Enedis, the major DSO on mainland France, contracted a 800 million EUR loan with the European Investment Bank in May 2022 to finance grid upgrades for decentralised generation and electric vehicle charging – for nearly 12 000 km of new distribution lines and associated transformation equipment.



3.9.2 Grid access policies

Recurring grid access fees (Tarif d'Utilisation des Réseaux Publics d'Electricité – TURPE) are paid by all users with contributions calibrated to cover all of a DSO's operating and investments costs, including the cost of capital. Access costs are determined according to

- voltage level of the user grid connection;
- the type of user (consumer/generator);
- and for certain users, the time of use.

Unlike many other European countries, there is no geographical differentiation of tariffs.

The total cost of the TURPE is defined by the energy regulator (CRE), directly defining DSO's revenue for public service type missions. The energy regulator also defines the cost sharing between types of users, based on a study of the users' impact on the network and the costs they generate.

The fee structure is based on cost components and adapted to voltage level and type of user and the principal components for generators are:

- Annual management component (CG)
- Annual metering component (CC)
- Annual injection component (CI) high voltage grid connections only
- Connection point grouping component (CR)
- Annual component of reactive energy (CER)
- Public service contribution (CSPE)

Costs have a significant capacity base but include an energy cost. Whilst grid access costs are generally not a significant part of OPEX costs, this does vary depending on the type of injection and the different legal entities attached to a system and consumption points - access fees for self-consumption systems are significantly lower than full sales systems as several cost categories are mutualised with the consumer fees.

The fixed part of annual access fees range from approximately 10 EUR/year for selfconsumption systems under 36kVA to approximate 760 EUR/year excluding VAT for systems connected to the medium voltage grid. For systems connected to the high voltage grid this as in the range of 10 000 EUR/year, whilst the energy injection component is 0.23 EUR/MWh, paid only on active energy.

Systems must be able to absorb reactive power, and whilst curtailment policies are limited to overseas territories (isolated grids) at this time, there is a push to use curtailment as a tool to permit limited grid connections on sections of network that require infrastructure works, and discussion on how this would affect grid access costs is ongoing.



4 INDUSTRY

4.1 **Production of ingots and wafers (crystalline silicon industry)**

Table 22: Silicon feedstock, ingot and wafer producer's production information for 2022.

Manufacturers	Process & technology	Estimated Total Production
Photowatt EDF ENR PWT	mc-Si wafers [MW]	75 MW

Photowatt (EDF ENR PWT) is a French wafer manufacturer and module supplier specialized in low carbon content solutions. It produces cast-mono silicon ingots, bricks and wafers (Crystal advanced process). In 2022, Photowatt was the first company in Europe to upgrade its production to the large format G12/210 mm.

ECM Technologies group, based in Grenoble and near Montpellier, focuses on supplying photovoltaic equipment manufacturing for the end-to-end value chain, from ingots to cells.

4.2 Production of photovoltaic cells and modules

Table 23: PV cell and module production and production capacity information for 2022

	Technology (sc- Si, mc-Si, a-Si,	Production and/or capacity (MW/year)	
Cell/Module manufacturer	OPV)	Cell	Module
Wafer-based PV manufactures			
EDF ENR PWT (Photowatt)	sc-Si	2	2
Reden Solar	sc-Si		65
Recom Techonologies	sc-Si		300
S'tile	sc-Si		40
Systovi	sc-Si		40
VMH Energies	sc-Si		60
Voltec Solar	sc-Si		200
Thin film manufacturers			
ARMOR	OPV	40	40
Dracula Technologies	OPV	/	/
Total			Approximately 800 MW

Sources: Le photovoltaïque: choix technologiques, enjeux matières et opportunités industrielles, French Ministry of Energy and Environment; interviews with manufacturers and Hespul estimates.



The national industry is relatively small, with several manufacturers targeting specific niche markets, often related to building integrated products (PV tiles, façade elements...), PV/thermal hybrid modules (Dualsun, Systovi...) or small-scale production runs and pre-industrial research (Photowatt, Irysolar...). This industry operates with strong public R&D/industry links.

In the past years, several manufacturers have increased their production capacity based on the favourable market visibility given by the national competitive tenders.

4.2.1 Small-scale producers of modules dedicated to the national or European market:

- **Recom Technologies**'s Lannion site production has a 300 MW/year capacity;
- **Sunpower (Total Group subsidiary)** closed its 2 plants in Moselle and Toulouse in 2022. The launch of production of a new ultra-thin elastic panel, announced for 2021, has finally been cancelled;
- Voltec Solar assembles modules on their Alsace site, its production capacity is 200 MW/year. A new production line is to be installed at the end of 2023 to reach a production capacity of 500 MW/year. Voltec, in partnership with IPVF, also announced its intention to launch the industrialisation of a 4T perovskite-silicon tandem technology developed in-house by IPVF, to reach a 200 MW industrial demonstrator in 2025. The company has launched the Belenos project with Systovi, which aims to reach a cumulative capacity of 1 GW/year for both manufacturers;
- **Reden Solar** manufactures modules, but also develops and operates photovoltaic power plants. It's semi-automated and automated production lines manufacture modules but also PV powered streetlamps, street furniture and solar thermal equipment. The company invested in a new halfcut-cell module production line with a capacity of 200 MW/year. It should start before the end of 2023. To consolidate Reden Solar's business development, Macquarie Asset Management, BCI and MEAG acquired Reden Solar for 2.5 billion EUR;
- VMH Energies production site is located in Châtellerault near Poitiers. Its production capacity is 60 MW per year. The recent crises are likely to have had a major impact on its production.

4.2.2 Integrated cells and modules manufacturers:

Photowatt (EDF ENR PWT) research and development concentrates on the emergence of new technological solutions and tests them in pre-industrial condition in its dedicated clean room, testing zone and qualification area.

4.2.3 Other markets: Photovoltaic tiled roofs, photovoltaic thin films and aerovoltaic modules:

• **Systovi** assembles monocrystalline modules. It mainly manufactures PV/thermal hybrid modules (hot air). Its manufacturing facilities are located at Carquefou, close to Nantes. The company, owned by the Cetih group, invest in a new production line in 2023 with a capacity of 80 MW/year. It is also preparing for an optional expansion to 350 MW/year with the possibility of using heterojunction technology. The company has launched the Belenos project with Voltec, which aims to reach a cumulative capacity of 1 GW/year for both manufacturers.



- S'Tile uses the technology known as i-cells, bi-glass and bifacial modules. Their modules are either integrated into buildings or integrated into off-grid systems. Over 2022 they have been active in repowering, replacing modules on damaged systems. This last activity accounted for half of their business in 2023. They develop made-to-measure photovoltaic modules, with annual production varying between 25 and 50 MW. Around 70 % of their production is sent to Europe, with only 30 % of modules destined for French installations.
- **ARMOR** develops proprietary organic "ASCA" films, targeting the market for connected devices, wearable photovoltaics as well as building integration applications (semi-transparent glazing...), with a manufacturing capacity of 1 million m²/year. The company invested 10 million euros a year in R&D and its production capacity.
- **Dracula Technologies** is a start-up developing printed organic photovoltaic cells (trademarked LAYER technology) aimed at the connected device market. Their cells capture ambient light, whether natural or artificial. Their modules have a standard surface area of 42 cm² and deliver a standard micro-power of 7.5 mW. Its pilot line was inaugurated in September 2019.
- **Solems SA** manufactures thin-film elements and modules up to 30 cm x 30 cm for connected devices and self-powered automates and building elements.
- **SolarCloth** develops flexible solar on different supports for integration onto canvas (tourism and agricultural uses) and vehicle roofs (with Renault Trucks).

Other operator's such as **Edilians**, manufacture PV tiles (size 45 cm × 31 cm and 136 cm × 50 cm respectively), while DualSun develops and markets photovoltaic-thermal hybrid modules (PV-T).

4.3 Manufacturing Projects

The Norwegian manufacturer **REC** has cancelled its plan to build a heterojunction module factory in Sarreguemines (Moselle) with a capacity of 2 GW/year (in 2022) then 4 GW/year (in 2025). A consortium called **Holosolis**, made up of EIT InnoEnergy, IDEC (a French property developer) and TSE (an utility scale and agrivoltaic developer), has announced that it is to set up a factory on the same site. Production is due to start in 2025, rising to 5 GW/year from 2027.

Carbon, a start-up with local industry backing aims to build an integrated plant producing 5 GW/year of cells and 3.5 GW/year of modules. The company has announced its intention to start production in 2025 at a site in Fos-sur-Mer near Marseilles.

4.4 Manufacturers and suppliers of other components

Balance of system component manufacture and supply is an important part of the PV system value chain. There are a number of French companies with an international presence providing a full range of electrical solutions for connection, conversion and management of photovoltaic systems. The France solar industry initiative is designed to showcase French know how across all solar technologies, and members are present from upstream (research and machine tools) all the way through the value chain from industry to support, installation and O&M.

PV inverters (for grid-connection and stand-alone systems)

Only a small handful of inverter manufacturers are French – a large multinational with a complete offer (string and centralised inverters), and other manufacturers with a small range of products targeting specific markets with (off grid, on grid, storage...).



Storage batteries

Market penetration remains very low for residential systems, although offers are present, and whilst national industry has international players (SAFT, EDF), deployment of large-scale storage is limited – mostly to overseas territories, although some projects on the mainland are supplying flexibility measures.

Supporting structures

A number of local manufactures of supporting structures exist; products range from PV tiles (Edilians, SunStyle), roof integration supports (IRFTS, bought by Edilians in early 2022) and GSE), pergolas (Mitjavila, Adiwatt) and residential car ports (IRFTS, Adiwatt, Carport Solaire...).

Solar parking supports are designed and manufactured by a number of companies present, with a range of materials used (wood, steel, aluminium).

Manufacturers of on-roof systems for industrial metallic roofs and bituminous or polymer roofs are also present, including Dome Solar, Solapro, Arcelor or Soprasolar.

A number of manufacturers of solar support *buildings* (agricultural hangars, greenhouses) are also present (Mecosun...).

With a unique lead on the international market, Ciel & Terre is a leading designer and manufacturer of floating photovoltaic supports and systems.



5 PV IN THE ECONOMY

5.1 Labour places

Table 24: Estimated PV-related full-time labour places

	Number of full-time (FTE) labour places		bour places
Market category	2019	2020	2021
Research and development (not including companies)	500		
Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D	700		
Distributors of PV products and installations	5 100		
Other	3 300		
Total	9 600	12 100*	33 000**

Sources: Évaluation et analyse de la contribution des EnR à l'économie de la France et des territoires 2020, SER, and Becquerel Institute France estimates.

*Etude ADEME "Marchés et emplois concourant à la transition énergétique" (2022),

** Solar Power Europe

While jobs related to the manufacture of photovoltaic equipment, R&D or the installation of photovoltaic systems are relatively stable, those dedicated to project development, studies and operations are growing rapidly. The rapid growth of the sector, and the lack of qualified manpower, has led to continued tensions in recruitment. Conversely, material shortages continuing from 2021 into 2022 continued to disrupt some companies. Major developers had ambitious recruitment plans through 2022, often citing a 15 % to 30 % increase in personnel planned to meet the demands of both their French market but also foreign offices (Urbasolar, Valorem, Green Yellow...)

The most recent Renewable Energy Market and Employment Study was published in September 2022 and covers 2020 direct employment data. Industry body Solar Power Europe's "EU Solar Jobs Report 2022" published in September estimates that there are 33 000 FTE in France in 2021.

5.2 Business value

Investments and turnover are studied by ADEME every two years in the study "Marchés et emplois liés à l'efficacité énergétique et aux énergies renouvelables".

The market value for 2022 (below) has been estimated based on 2022 trending prices and rectified 2022 grid connection volumes. Data accuracy may be compromised by the use of trends costs (these costs are from a reduced sample across France and may not accurately reflect real costs) and the volume estimate spread across segments for Industrial systems with power above 250 kW and ground-mounted systems. The following table represents the value



of investments in commissioned PV systems, and not the value of the market itself that includes future systems, services, research and other sectors.

Sub-market	Capacity installed in 2022 [MW DC]*	Average price [EUR/W]	Estimated value M EUR
Off-grid			
Residential < 3 kW	124	2.4	247
Residential < 9 kW	283	2.2	519
Commercial < 100 kW	678	1.1	622
Commercial < 250 kW	194	0.9	146
Industrial > 250 kW	101	1	84
Grid-connected distributed	1 380	1.17	1 618
Grid-connected centralised	1 586	0.74	978
Estimate	2 400 to 2 700**		

Table 25: Estimation of the value of the PV business in 2022 (VAT is excluded)

SOURCE: SDES, Enedis, BI France

** A range is published due to the approximate nature of data.

6 INTEREST FROM ELECTRICITY STAKEHOLDERS

6.1 Structure of the electricity system

With a highly concentrated electricity the 100% state owned EDF and its different wholly or partially owned subsidiary companies are the principal generator, transport grid manager, distribution grid manager and retailer. In response to the open market European Directives, the different entities are legally separate, with grid management missions run as "delegated public services". The EDF group has an extensive portfolio of nuclear and renewable energy sites.

Secondary operators include the generator Engie (the state holds over 20 % of the share capital) and municipal DSO's (they cover about 5 % of the population).

The National Energy Regulator, Commission de régulation de l'énergie (CRE) is an independent administrative authority and supervises market regulations, grid access conditions and manages competitive tender processes based on rules established by the government. They also judge grid access conflicts and are a mandatory consultative body for changes to the legislative and regulatory energy framework.



6.2 Interest from electricity utility businesses

In France the only private electricity utility is EDF (fully owned by the State as of June 2023 after a buyback of remaining stock in 2022), that covers 95 % of the population - all other utilities are (generally very small) public entities – a legacy of the post-war nationalisation of private electricity companies.

EDF and its subsidiary companies are major players in photovoltaics, with branches dedicated to different market segments present in France and across the world. EDF Renouvelables (EDF Renewable for the international branch – centralised photovoltaics), EDF Renouvelables Services (O&M services in Europe), EDF Energie Nouvelles Réparties (EDF ENR - residential and small commercial systems), Sunzil (operating in the Caribbean and other isolated/off grid areas) and Agregio (electricity aggregation for the market) are all active in France. EDF EN Photowatt is a photovoltaics manufacturer.

EDF is also active in R&D activities through both EDF internal research departments, research partnerships with public research organisations and Photowatt. Through its different subsidiaries, EDF has a worldwide portfolio with 4.3 GW in construction and 7.4 GW already installed (total or partial ownership).

ENGIE is a gas utility also present in the development and generation of electricity capacity - and has the biggest solar portfolio in France with 9 % of the national market and 5.3 GW worldwide.

6.3 Interest from municipalities and local governments

Almost all local authorities have climate energy plans that are generally ambitious in terms of photovoltaic development. This is one of the reasons why municipalities and local governments continue to be active participants in the growth of photovoltaics in France, both investing in projects, experimenting innovative projects (particularly collective self-consumption), and facilitating citizen investment and grid integration. Many have created public-private development and investment companies to both facilitate project development without the constraints of public procurement, but also serve as a vehicle for their projects.

7 HIGHLIGHTS AND PROSPECTS

7.1 Highlights

The impact of conflict in Ukraine and delayed maintenance on nuclear power stations in France led to constrained generation capacity and unprecedented electricity prices, a strong case for solar as both a tool to contain electricity bills for consumers but also as a long-term answer to national security of supply. Recognising their key role in this context, a law was tabled in 2022 to "accelerate" the deployment of renewables in France, although the law published in 2023 was met with mixed reception, many feeling that it added new brakes in some areas and being insufficient in others.

The increased price of electricity on the market validated the governments choice to use Contracts for Difference (CfD) in the national competitive tenders, as market prices grew higher than the guaranteed remuneration, leading to an estimated 700 million euros being paid back



to the government from generators benefiting from CfD contracts. The reverse side of this was that the attractive electricity market, coupled with still high material costs for PV led to competitive tenders being largely undersubscribed as the larger developers looked to more attractive corporate PPA conditions – although the volume of PPA's announced over 2022 remained relatively low, in no way reaching the volume that could potentially have been awarded in tenders. In an effort to compensate the increased material costs across 2021 and 2022 that put already awarded capacity at CfD tariffs below a viable level in jeopardy, a modification to tender specifications meant that generators could sell directly on the market for a short initial period to build cash flow.

In line with the ballooning electricity costs, the residential market saw substantial growth with nearly double the number of systems, whilst collective self-consumption projects grew as well.

In 2022, national photovoltaic capacity grew by 2.9 GW DC, (down from 2021's 3.3 GW DC but still well above 2020's 1 GW), for a cumulative capacity of roughly 20 GW DC for grid connected installations. Just over half of new capacity is industrial and utility scale systems (down from 2/3 in 2021), highlighting the fragility of the French market to the development of utility scale systems.

Approximately 20 % of the new capacity is with some form of self-consumption (up from 10 % on 2021 – and although self-consumption models remain marginal for industrial systems, over 85 % of capacity for new residential and small (under 100 kW) commercial systems have self-consumption, generally associated with feed in tariffs for net billing.

In France projects progress from gaining urban planning approval (permitting) to entering the grid connection queue to commissioning. Over 7 GW DC of new projects entered the grid connection queue in 2022, and with only 3 GW DC of commissioned projects, the stock grew to around 20 GW DC of projects, including over 4.5 GW with DSO contracts (up from 3 GW DC last year), and an unknown capacity with the TSO. The 2021 framework for feed in tariffs maintained strong growth in the 100 kW to 500 kW segment, with 1.5 GW DC of projects in this segment having signed DSO contracts but not yet commissioned in this segment (up from 280 MW in 4th quarter 2021).

7.2 Prospects

With continued high electricity prices solar will remain attractive in the residential and commercial segments, with continued growth expected. In parallel, the high volume of generation capacity in the grid connection queues should lead to reasonable volumes of commissioning in 2023 and stronger volumes in 2024. As 2021 legislation on mandatory solar or living roofs on commercial buildings comes into force, and corporations become more aware of their fragility with regards to volatile electricity markets, the grid connection queue should also grow strongly over 2024. Structurally long lead times due to permitting and administrative procedures will remain a barrier, as too will public acceptance towards utility scale projects on farming or unused land. 2023 should see volumes roughly equivalent or slightly below 2021.