Technology Collaboration Programme
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International Energy Agency
Photovoltaic Power Systems Programme

PVPS

National Survey Report of PV Power Applications in France

2020

ADEME
AGENCE DE LA TRANSITION ÉCOLOGIQUE

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 2020. Information from this document will be used as input to the annual Trends in photovoltaic applications report.

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COVER PICTURE

100 kW citizen investment system on the Emile Anthoine Sports Complex Paris image credit: Enercitif

TABLE OF CONTENTS

Acknowledgements 4
REFERENCES 4
1 Installation Data 5
1.1 Applications for Photovoltaics 5
1.2 Total photovoltaic power installed 6
1.3 Key enablers of PV development 11
2 Competitiveness of PV electricity 12
2.1 Module prices 12
2.2 System prices 13
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 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 25
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 32
3.7 Retroactive measures applied to PV 32
3.8 Indirect policy issues 32
3.9 Financing and cost of support measures 33
4 Industry 34
4.1 Production of feedstocks, ingots and wafers (crystalline silicon industry) 34
4.2 Production of photovoltaic cells and modules (including TF and CPV) 34
4.3 Manufacturers and suppliers of other components 37
5 PV in the Economy 38
5.1 Labour places 38
5.2 Business value 39
6 Interest From Electricity Stakeholders 40
6.1 Structure of the electricity system 40

6.2 Interest from electricity utility businesses 40
6.3 Interest from municipalities and local governments 41
7 Highlights and Prospects 42
7.1 Highlights 42
7.2 Prospects 42

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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° 343, February 2021 (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)
- "Coûts et rentabilités du grand photovoltaïque en métropole continentale", Commission de Régulation de l'Energie, March 2019
- "Bilans des Raccordements", Enedis Open Data (distribution grid manager for 95 % of the nation)
- "Bilan électrique 20120" (RTE Electricity Report 2020), RTE, March 2021 (Transport grid manager)
- "Baromètre annuel 2020", AVERE
- "Rapport d'activité – Installations de production", Consuel, 2017 à 2020
- "Charges de service public de l'énergie prévisionnelles au titre de l'année 2020", CRE
- France Territoire Solaire Bilan 2020,
- "Baromètre 2020 du crowdfunding EnR", Green Univers,
- "Le baromètre 2020 des énergies renouvelables électriques en France", Observ'ER
- 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, 2020 and 2021)
- "Évaluation et analyse de la contribution des énergies renouvelables à l'économie de la France et de ses territoires" SER/EY June 2020
- "Le photovoltaïque : choix technologiques, enjeux matières et opportunités industrielles" CGDD, French Ministry of Energy and Environment
- EDF Faits et chiffres, EDF, 2021

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 2020 statistics if the PV modules were installed and connected to the grid between 1 January and 31 December 2020, although commissioning may have taken place at a later date.

Data collection does not yet include information on storage capacity, however 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 beinf indicated in by 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 and in overseas territories will generate more, up to 1 400 kWh/kW.

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 market segments in France in 2020 are grid connected:

- Residential (house and multi-apartment) building integrated systems (0 kW to 36 kW)
- Commercial, agricultural or industrial building integrated systems (36 kW to 250 kW)
- Industrial building mounted or parking canopy systems (250 kW to 3 MW)
- Centralised ground mounted systems (over 1 MW)

This market segmentation is a result of the different support mechanism structures and grid-connection requirements.

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

Self-consumption has now become the norm for residential systems, with 75 % of new grid connection requests (in cumulative power in the segment), compared to 65 % in 2019, 55 % in 2018 and around 30 % in 2017 for this segment. Systems under 36 kW remain approximately 12 % of installed PV volumes. A 50% jump in connected volumes was noted in the fourth quarter, but it is still too early to determine whether this is associated with a cyclical or structural strengthening of the market.

Small commercial systems volumes for the 36 kW-100 kW segment continued to grow from 22 % of installed capacity in 2019 to more than 32 % in 2020. This represented the vast majority of installed capacity (in terms of power) on commercial buildings in 2020. The strong growth in this segment also offsets the decline in the rate of installation of larger installations.

Commercial systems over 100 kW and below 250 kW represented only 62 MW in 2020, or just over 6 % of the year's installed capacity. These building mounted or parking canopies systems were awarded a feed-in-tariff through the framework of national Tenders, in major part by France's major development companies.

Multi-megawatt systems (building or ground-based systems) were exclusively within the framework of national tenders (only existing support scheme for systems of over 100 kW) and

represented nearly 40 % of new capacity (391 MW in 2020), however this is expected to be the last year, as a number of PPA's for new capacity were announced.

The French photovoltaic industry has been relatively unaffected by the COVID-19 crisis. Industry professionals present on the small to medium systems segment indicated that the impacts of the March 2020 COVID-19 lockdown were recovered in the second semester. The March lockdown may have led to postponements of commissioning, which could explain the rebound in connections observed in the second half of the year.

1.2 Total photovoltaic power installed

Centralized: any PV installation which only injects electricity and is not associated with a consumer (no self-consumption) over 250 kWp

Decentralized: any PV installation which is embedded into a customer's premises (either with or without self-consumption) under 25 kWp

Cumulative PV installed capacity as of the end of 2020 reached 10 890 MW (AC — Alternative Current). Cumulative PV installed capacity by application is 30 MW for off-grid and 10 860 MW for grid-connected.

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 is given as the AC power of system, whilst Enedis does not specify if the data is DC or AC. 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.

For the purposes of this report, we have considered the following hypotheses for 2020 data:

Grid connected distributed (decentralized) systems:

- Residential: up to 9 kW - no data are available concerning the split BIPV/BAPV;
- 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.

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 2020

		Installed PV capacity in 2020 [MW]	AC or DC
	Decentralized	513	AC
	Centralized	460	AC
	Off-grid	/	
	Total	973	AC

SOURCE: SDES, Observ'ER, Enedis, *estimated HESPUL

Table 2: PV power installed during calendar year 2020

			Installed PV capacity in 2020 [MW]	Installed PV capacity in 2020 [MW]	AC or DC
Grid-connected	BAPV	Residential	537	110*	AC
		Commercial		403	AC
		Industrial		24*	AC
	BIPV	Residential	No data available as feed-in tariff bonus for BIPV has been stopped	/	AC
		Commercial		/	AC
		Industrial		/	AC
	Utility-scale	Ground-mounted	436	436*	AC
		Floating		/	AC
		Agricultural		< 1*	AC
Off-grid		Residential	No data available		AC
		Other			AC
		Hybrid systems			AC
Total			973		AC

SOURCE: SDES, France Territoire Solaire, Enedis *estimated HESPUL

Table 3: Data collection process

Conversion coefficient to estimate DC installations.	115 %. This is standard inverter dimensioning practice in mainland France
Body collecting data	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. HESPUL has extrapolated and estimated data where these sources had no published data.
Link to official source	https://www.statistiques.developpement-durable.gouv.fr/les-energies-renouvelables?rubrique=21
Data quality	Data is provisional, and may be revised as grid operators provide additional information. Divergence in capacity volumes may exist; the error source may be related to reporting dates, provisional data and/or collection methods. Historical data may be in DC.

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

Year	Off-grid [MW] (including large hybrids)	Grid-connected distributed [MW] (BAPV, BIPV)	Grid-connected centralized [MW] (Ground, floating, agricultural…)	Total [MW]
2008	22,9	150	7	179,9
2009	29,2	300	42	371,2
2010	29,3	938	242	1 209,3
2011	29,4	2 242	702	2 973,4
2012	29,6	3 052	1 012	4 093,6
2013	29,7	3 454	1 264	4 747,7
2014	29,75	3 963	1 709	5 701,75
2015	30,15	4 257	2 318	6 605,15
2016	30,15*	4 573	2 598	7 201,15
2017	30,15*	4 985	3 084	5 015,15
2018	30,15*	5 342	3 596	8 961,15
2019	30,15*	5 796	4 121 (revised)	9 934,15
2020	30,15*	6 309	4 581	10 890,15

SOURCE: SDES and previous IEA NSR-FR reports (revised), PV Atlas Observ'ER and ADEME

* No data available

Table 5: Other PV market information

<table>
<tr><td></td><td>2020</td></tr>
<tr><td>Number of PV systems in operation in your country</td><td>
<table>
<tr><th>Peak Power range</th><th>Installations (number)</th><th>Power [MW]</th></tr>
<tr><td>0 – 3 kW</td><td>332 299</td><td>898</td></tr>
<tr><td>3 kW–9 kW</td><td>102 952</td><td>642</td></tr>
<tr><td>9 kW–36 kW</td><td>21 226</td><td>522</td></tr>
<tr><td>36 kW–100 kW</td><td>20 718</td><td>1 738</td></tr>
<tr><td>100 kW–250 kW</td><td>7 405</td><td>1 346</td></tr>
<tr><td>> 250 kW</td><td>1 875</td><td>5 714</td></tr>
<tr><td>Total</td><td>486 475</td><td>10 860</td></tr>
<tr><td>Total Off-grid</td><td></td><td>30</td></tr>
</table>
</td></tr>
<tr><td>Capacity of decommissioned PV systems during the year [MW]</td><td>0 (estimated)</td></tr>
<tr><td>Capacity of repowered PV systems during the year [MW]</td><td>0 to 10 (estimated)</td></tr>
<tr><td>Total capacity connected to the low voltage distribution grid [MW]</td><td>484 600 systems for 5 146 MW</td></tr>
<tr><td>Total capacity connected to the medium voltage distribution grid [MW]</td><td>1 799 systems for 5 065 MW</td></tr>
<tr><td>Total capacity connected to the high voltage transmission grid [MW]</td><td>76 systems for 649 MW</td></tr>
</table>

Sources: SDES, Registre national des installations de production et de stockage d'électricité (2020), Open data réseaux énergies (ODRÉ) and Hespul extrapolations.

Table 6: PV power and the broader national energy market

	Data	Year
Total power generation capacities [GW]	Total: 136,2 GW of which • Nuclear: 61,37 GW; • Fossil fuel: 18,93 GW; RES: 53,581 GW (see below)	2020
Total renewable power generation capacities (including hydropower) [GW]	• PV*: 10,387 GW (7,5 %); • Hydro: 25,731 GW; • Wind: 17,616 GW; • Other RES: 2,171 GW	2020
Total electricity demand [TWh]	460 TWh	2020
New power generation capacities installed [GW]	Total: 2,295 GW of which • Gas: +0,371 GW; • Coal: 0 GW; • Diesel: 0,022 GW; • Nuclear: - 1,76 GW; PV and other RES: 2,019 GW (see below)	2020
New renewable power generation capacities (including hydropower) [GW]	• PV*: + 0,82 GW; • Wind: + 1,105 GW; • Hydro: + 0,028 GW; • Other RES: + 0,066 GW	2020
Estimated total PV electricity production (including self-consumed PV electricity) in [TWh]	PV: 12,6 TWh	2020
Total PV electricity production as a % of total electricity consumption	2,7 %	2020
Average PV yield in [kWh/kW]	1 160 kWh/kW (30° with system losses (PV GIS) – France mainland) Ranges from 900 kWh/kW to 1 550 kWh/kW (30° with system losses (PV GIS) – continental France)	2020

2020: RTE France Electricity Report 2020. *RTE provisional PV figures differ from those of SDES, Tableau de bord: solaire photovoltaïque in Q4 2020.

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

1.3 Key enablers of PV development

Table 7: Information on key enablers

	Description	Annual Volume (Number of units)	Total Volume	Source
Decentralized storage systems	On residential sites	Mainland France: 1 267 Overseas: 299	Mainland France: 10 000 Overseas: 800	www.consuel.com Consuel Rapports d'activité 2020, 2019, 2018,
	Other sites	Mainland France: 44 Overseas: 18	Mainland France: 130 Overseas: 60	www.consuel.com Consuel Rapports d'activité 2020, 2019, 2018, 2017
Residential Heat Pumps	Mono and multi-split reversible heat pumps	812 404	5 058 235	www.uniclima.fr Uniclima: Bilan 2020 et perspectives 2021 du génie climatique
	Thermodynamic domestic water heater	110 320	717 771	
	Total since 2012	922 724	5 776 006	
Electric cars	Cars	44 969	211 680	www.avere-france.org AVERE: Bilan 2020
	Lightweight utility vehicles	3 892	52 229	
	Hybrid rechargeable cars	20 308	77 624	
	Total since 2010	69 169	341 533	

Note 1: the "Uniclimat Bilan" comments that "there appears to be a market for replacing heat pumps that were initially installed after the 2003 heatwave", and also that "Thermodynamic domestic water heaters in particular fulfil requirements for RES in new buildings".

Note 2: decommissioned units are not accounted for, thus the total volume may not represent the total volume in service.

2 COMPETITIVENESS OF PV ELECTRICITY

Costs continued to decrease in France, as across the world, mainly due to a reduction in module and inverter costs. However, grid connection costs remain a determining factor for many projects despite some of the costs being mutualised through annual grid access fees. The impacts of the COVID-19 lockdown in March and partial lockdown in November were mostly limited to supply chain issues. However, from September 2020, module prices started increasing (approx. +25 % over 3 months, depending on suppliers). For residential systems the module costs increase had a lower impact on market prices as incompressible costs such as labour and insurance are proportionally higher.

French government support meant that during the lockdown, when all site work ceased, salary costs were subsidised to a high level by government, with little financial impact to clients.

Data on market prices is published irregularly, based on either surveys or, when published by the Energy Regulation Commission, data provided by tender candidates. 2020 data are based on limited market surveys conducted for the purposes of this report.

2.1 Module prices

A 2019 study by the Energy Regulation Commission (CRE) provides the most recent large-scale 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.

Table 8: Typical module prices (€/Wp) for a number of years

Year	2016	2017	2018	2019	**Typical price of a standard module crystalline silicon** 2020
Average module price (all technologies) for systems in Tenders	0,7	/	/		0,35-0,4*
Average module price (all technologies) for systems in Building Applications PV Tenders Over 90 % of modules in the survey were monocrystalline silicon		0,6	0,6	0,45	
Average module price (all technologies) for systems in ground based PV Tenders 60 % of modules in the survey were monocrystalline silicon,		0,55	0,4	0,4	

13 % polycrystalline silicon and 27 % thin film technologies				

SOURCE: CRE "Coûts et rentabilités du grand photovoltaïque en métropole continentale", pvXchange and Hespul estimate. 2020 data from Hespul 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.

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

Category/Size	Typical applications and brief details	Current prices [€/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. Equipement 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. Equipement and labour.	1,7 – 2,0
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. Equipement and labour.	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. Equipement and labour. Grid connection not included.	0,6 - 1,7
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. Grid connection not included.	0,7 - 1,0
Industrial BAPV >250 kW	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity to grid-connected industrial buildings, warehouses, etc. Grid connection not included.	0,9 - 1,1
Small centralized PV 1-10 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	0,5 - 0,9

	electricity for sale. With few exceptions, financed through competitive tender	
Medium centralized PV 10-20 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. With few exceptions, financed through competitive tender	0,5 - 0,9
Parking canopies up to 5 MW	Grid-connected, distributed PV systems installed over impermeable car parks to produce electricity to grid-connected industrial buildings, warehouses, etc. Financed through competitive tender	1,2 - 1,3
Parking canopies 5 to 10 MW	Grid-connected, distributed PV systems installed over impermeable car parks to produce electricity to grid-connected industrial buildings, warehouses, etc. Financed through competitive tender	1 – 1,1
Floating centralised PV	Financed through competitive tender	1

SOURCE: FiT systems: estimation HESPUL from sources Hespul. Tenders source: CRE “Coûts et rentabilités du grand photovoltaïque en métropole continentale”, Etude ADEME “Coûts des énergies renouvelables et de récupération en France”.

Table 10: National trends in system prices for different applications

Year	Residential BAPV Grid-connected, roof-mounted, distributed PV system 5-10 kW **[euro/W]**	Small commercial BAPV Grid-connected, roof-mounted, distributed PV systems 10-100 kW **[euro/W]**	Large commercial BAPV Grid-connected, roof-mounted, distributed PV systems 100-250 kW **[euro/W]**	Centralized PV Grid-connected, ground-mounted, centralized PV systems 10-50 MW **[euro/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

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, limited market surveys by Hespul, 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.

Table 11: Cost breakdown for a grid-connected roof-mounted, distributed residential PV system of 10-100 kW

Cost category	Average [€/W]
Hardware	
Module	0,37
Inverter	0,07
Mounting material	0,32
Other electronics (cables, etc.), including installation	0,33
Subtotal Hardware	1,09
Soft costs	
Installation work	(included in Other Hardware costs)
Planning	0,1
Shipping and travel expenses to customer	
Customer acquisition	
Permits and commissioning (i.e. cost for electrician, etc.)	
Project margin	
Subtotal Soft costs	
Grid connection	0,2
Total (excluding VAT)	**1,43**
Average VAT	20 %

SOURCE: "Évaluation et analyse de la contribution des énergies renouvelables à l'économie de la France et de ses territoires" SER/EY June 2020

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

Table 12: Cost breakdown for a grid-connected, ground-mounted, centralized PV systems of >1 MW

Cost category	Average [€/W]
Hardware	
Module	0,3
Inverter	0,06

Mounting material	0,16
Other electronics (cables, etc.), including installation	0,17
Subtotal Hardware	**0,69**
Soft costs	
Installation work	(included in Other Hardware costs)
Planning	0,13
Shipping and travel expenses to customer	
Customer acquisition	
Permits and commissioning (i.e. cost for electrician, etc.)	
Project margin	
Subtotal Soft costs	
Grid connection	0,08
Total (excluding VAT)	**0,87**
Average VAT	20 %

SOURCE: “Évaluation et analyse de la contribution des énergies renouvelables à l’économie de la France et de ses territoires” SER/EY June 2020

2.4 Financial Parameters and specific financing programs

Table 13: PV financing information in 2020

Different market segments	Loan rate [%]
Average rate of loans – residential installations	4 % - 7 % over 12 years
Average rate of loans – commercial installations	1,5 % over 18 years
Average cost of capital – industrial and ground-mounted installations	3 % over 20 years

SOURCE: Etude ADEME “Coûts des énergies renouvelables et de récupération en France”, CRE “Coûts et rentabilités du grand photovoltaïque en métropole continentale”, ISWT, estimation Hespul.

Note: Rate of loans for residential applications are often consumer credit type which explains their relatively high level. Interest rates dropped as financing organisations benefited from COVID-19 national economic stimulus packages.

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. Not common.
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 plants)	Crowd-funding generally finances debt through crowd-funding platforms, however some platforms allow for equity financing. 60 % of projects in the competitive tenders for ground-based systems were eligible for the crowdfunding or community solar bonus, but only approx. 20 % for the roof-mounted photovoltaics tenders.
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).

With a growing demand for recognised “green” finance labels, the Greenfin label, which aims at guaranteeing the environmental criteria of investments (specifically related to energy transition) and the respect of a certain number of additional financial criteria including transparency went from 19 (end 2019) to 59 funds (mid 2021) – although not all are open for photovoltaics - some are technology specific (for example, wood or “green” gas).

Cleantech investments in France grew again in 2020, with the RES sector being the biggest beneficiary. Significantly, it was photovoltaics generator Amarenco’s two operations, raising 163 million euros, that were the biggest events of the year.

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. A risk-sharing project with financial institutions implemented in 2017 was replicated in 2018, and will operate until 2022, with a project investment cost of 1 800 MEUR for renewable energy plants including photovoltaics. In 2020, the EIB invested 75 million euros in INFRAGREEN IV, a Greenfin label fund with 26 million euros for France.

Other major actors include La Banque des Territoires (Caisse des Dépôts) and its subsidiary Bpifrance, who jointly launched a 40 billion euro Climat Plan in September, with 900 million euros for direct investment in renewable energy infrastructure over the next 5 years by La Banque des Territoires.

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 institutions that provide debt financing or leasing options for energy efficiency and renewable energy projects by municipalities, social housing organisation, commercial companies and agricultural companies.

As part of their Plan Climat (see above) announced in September, Bpifrance will double its project co-financing, partnering with private banks, and has reserved 12,7 billion euros for renewable energy project pre-financing over 4 years. A 100 million euro envelope has also been reserved for funding public and private self-consumption project loans.

Community solar (citizen investment)

Citizen investment is mobilised through specific citizen RES funds and crowd-funding platforms—financing both equity and debt. The principal organisations active in channelling citizen investment are crowdfunding platforms (debt and equity investments) and Energie Partagée (over 2 million euros invested in photovoltaics). Since its creation in 2009, Energie Partagée has invested 6,1 million euros in 35 photovoltaics projects for 42 MW (in

development or operations), representing 3 600 citizens and 83 local authorities. Another 30 MW of projects have been recognised as respecting the Energie Partagée charter – mostly smaller clustered projects carried by members of the Association Centrales Villageoise.

Crowdfunding

Crowdfunding of projects once again increased in volume in 2020. Historically crowdfunding serviced project debt, however just under 20 % of project financing went to equity- and just over 20 % of the total collected went to corporate financing, not project financing, a significant development.

Financing of photovoltaics through crowdfunding:

- Roof-mounted systems: 30 million euros raised for 250 MW across 77 projects,
- Ground-based systems: 33 million euros raised for 669 MW across 84 projects.

Residential project financing

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

2.6 Additional Country information

Table 15: Country information

Retail electricity prices for a household	Time of use contracts available. Eurostat Band DC (2 500 kWh < consumption < 5 000 kWh) • 195,8 €/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): • 127 €/MWh excluding VAT and other recoverable taxes and levies: • 152 €/MWh all taxes and levies included. Eurostat Band IC (500 MWh < consumption < 2 000 MWh): • 95 €/MWh excluding VAT and other recoverable taxes and levies: • 114 €/MWh all taxes and levies included.
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): • 81 €/MWh excluding VAT and other recoverable taxes and levies; • 96 €/MWh all taxes and levies included.
Liberalization of the electricity sector	France's electricity industry is highly concentrated but not vertically integrated in theory. However, in practice, EDF, (the state holds over 80 % of EDF share capital) 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) 2020S2

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 16: Summary of PV support measures

Category	Residential		Commercial + Industrial		Centralized	
Measures in 2020	**On-going**	**New**	**On-going**	**New**	**On-going**	**New**
Feed-in tariffs	Yes	-	Yes, (competitive Tenders)	-	-	-
Feed-in premium (above market price)	-	-	Yes, (competitive Tenders (national) and for Fessenheim territory)		Yes, (competitive Tenders (national) and for Fessenheim territory)	
Capital subsidies	-	-	Yes, some regions	-	-	-
Green certificates	-	-	-	-	-	-
Renewable portfolio standards (RPS)	-	-	-	-	-	-
Income tax credits	-	-	-	-	-	-
Self-consumption	Yes	-	Yes	-	-	-
Net-metering	-	-	-		-	-
Net-billing	Yes	-	Yes	-	-	-
Collective self-consumption and virtual net-metering	Yes	Yes (perimeter extended)	Yes	Yes (perimeter extended)	-	-
Sustainable building requirements	Yes	-	Yes	Yes – mandatory solar or	-	-

				living roof on commercial or industrial buildings and covered car parks occupying over 1000 square meters of ground		
BIPV incentives	-	-	-	-	-	-

3.1 National targets for PV

France adopted its revised National Low Carbon Strategy (SNBC) in April 2020 after a lengthy consultation process. The strategy provides guidelines to an "ecological and inclusive transition towards carbon neutrality" by 2050, as it sets carbon budgets that are in principal legally binding for the public sector. Within the SNBC, PV is seen as a tool to bring the building sector to rely exclusively on carbon-free energy sources (particularly in overseas territories). The agricultural sector is identified as a segment for which buildings could be used for deploying photovoltaics on a large scale. For the energy sector, the strategy includes guidelines to "pursue and bolster measures favouring the development of renewable energies."

The SNBC project was partially built on a modelling process used to establish the revised Multi-Annual Energy Programming (PPE), adopted in April 2020.

The revised PPE establishes targets for the development of photovoltaics in France, setting a goal of 20,6 GW for 2023 (up from the previous PPE's 18,2 GW to 20,2 GW) and 35,6 GW to 44,5 GW for 2028. Hitting this target means reaching an installation rhythm of around 4 GW per year, in other words multiplying by 4 last year's rhythms. France's strategy relies mainly on competitive tenders: 2 GW per year for ground-mounted projects, and around 1 GW per year for commercial / industrial BAPV. A target of 300 MW per year for Open Volume Feed-in Tariffs is also set-up for commercial and residential BAPV.

3.2 Direct support policies for PV installations

The measures summarized in table 15, and their effectiveness, are described below.

Support measures include, for individual self-consumed electricity from systems under 1 MW, exemption from the CSPE surcharge, local electricity and grid taxes and VAT (these taxes and levies normally represent approximately 30 % of a consumer's electricity bill). Property tax exemptions for agricultural and public-sector buildings equipped with photovoltaic systems are also in place, and thermal and environmental building regulations that should encourage the use of photovoltaics on new buildings.

3.2.1 Open volume feed-in tariffs for BAPV

Feed-in tariffs and net-billing with uncapped volumes for building applied systems under 100 kW levels 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 16a and 16b detail 4th quarter 2019 tariff levels.

Table 17 — Feed-in Tariff and Tender remuneration levels –Mainland France

Tariff category	Power of PV installation	Tariff Q4 2019 (EUR/MWh)
Continental France — building applied PV		
Ta (no self-consumption)	≤3 kW	179,7
Ta (no self-consumption)	3 kW to 9 kW	152,7
Tb (no self-consumption)	9 kW to 36 kW	113,5
Tb (no self-consumption)	36 kW to 100 kW	98,7
Call for Tenders	100 kW — 500 kW Building applied systems	Last 2020 average selling price (average EUR/MWh) 94*

* for projects that will be built in 2022

Table 18: Feed-in Tariff and Tender remuneration levels–Overseas France

Tariff category	Power of PV installation	Tariff Q4 2020 (EUR/MWh)
Tariff base		8,58
Sample system in Guadeloupe	2 kW	197
Sample system in Corsica	8 kW	154,5
Sample system in Réunion	50 kW	137,3
Power factor		
≤3 kW 3 kW to 9 kW 9 kW to 36 kW 36 kW to 100 kW	1,35 1,2 1,1 1 0	= 8,58 x 1,35 x location factor = 8,58 x 1,2 x location factor = 8,58 x 1,1 x location factor = 8,58 x 1x location factor = 0
Location factor		
Guadeloupe & Martinique Corsica Réunion French Guiana Mayotte	17 15 16 18 19	= 8,58 x 17 x power factor = 8,58 x 15 x power factor = 8,58 x 16 x power factor = 8,58 x 18 x power factor = 8,58 x 19 x power factor

Note: To calculate overseas tariffs, multiply the trimestral tariff base by the power factor and a location factor—for exact tariffs, refer to CRE publications.

Note: 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 100 kW to 30 MW are segmented according to size and application (building applications, ground based etc.). As a result, developers obtain either a feed-in-tariff (under 500 kW) or feed-in premium.

Fifteen competitive Tenders were held in 2020 either in mainland France or overseas territories, for a total volume of 2,1 GW: for building applied, for ground-based systems, for self-consumption systems, for innovative systems, and two for the Fessenheim territory (related to the decommissioning of the Fessenheim nuclear power plant) and four for overseas territories (see section 3.4).

3.2.3 BIPV development measures

In 2020 there were no specific BIPV development measures, however a number of indirect measures include thermal regulations and mandatory solar or living roofs for commercial and industrial buildings or covered car parks occupying more than 1000 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. In particular, the “Bâtiments à Energie Positive et Réduction Carbone (E+/C-)” label currently prefigures future building thermal regulation that will come into force in 2022. The future regulation should include a new set of criteria on energy and carbon, also applied to photovoltaics equipment.

A tax credit for the elements producing thermal energy is available for residential hybrid PV-T systems as well as for some energy management systems.

3.3 Self-consumption measures

Table 19: Summary of self-consumption regulations for small private PV systems in 2020

PV self-consumption	1	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.
	2	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 100 kW to 1 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.
	3	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	4	Revenues from excess PV electricity injected into the grid	Net-billing set by FiT (6 to 10 c€/kWh), or by Tender specifications (FiT or wholesale market + premium) or by PPA (Power Purchase Agreement). This does not apply to collective self-consumption.
	5	Maximum timeframe for compensation of fluxes	30 minutes.
	6	Geographical compensation (virtual self-consumption or metering)	Called “collective self-consumption” in France. Participation in a collective self-consumption operation is limited to 3 use cases: • ***Default case:*** PV installations and consumers located in the same building. This opens the possibility for the participation of medium voltage connected PV installations (which was not the case prior to the Energy-Climate Law enacted in November 2019); • ***Extended case***: PV installations and consumers connected to the low voltage grid within a distance of 2 km of each other (previously this perimeter was the MV/LV substation); • *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 case, generators(s) and consumers(s) must be linked through a common legal entity. Compensation on a 30 minute time-step.
Other characteristics	7	Regulatory scheme duration	20 years for surplus (net-billing) sold in FiT, 10 years in Self-Consumption Tender.

	8	Third party ownership accepted	Third party ownership is allowed.
	9	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.
	10	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.
	11	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 100 kW on buildings for access to net-billing and lump-sum within FiT framework. Systems must be between 100 kW to 1 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 (since the law of 21st of November 2019 establishing the geographical proximity criteria for extended collective self-consumption).
	12	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 % of consumption, grid manager disconnects on a first installed-last disconnected priority order).
	13	Additional features	Markets sales of surplus in the framework of Tenders require access to an Aggregator/Balancing Responsible Party.

			Collective self-consumption systems cannot access FiT for excess production sales. Several virtual battery storage offers are available.

3.3.1 Net-billing feed-in tariff and lump sum for BAPV systems under 100 kW

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

Tariff category	Power of PV installation	Net-billing tariff (+ lump sum) Q4 2019 (EUR/MWh)
Continental France — building applied PV		
Pa (net-billing)	≤3 kW	100 (+0,38 EUR/W installed)
Pa (net-billing)	3 kW to 9 kW	100 (+ 0,28 EUR/W installed)
Pb (net-billing)	9 kW to 36 kW	60 (+ 0,17 EUR/W installed)
Pb (net-billing)	36 kW to 100 kW	60 (+ 0,08 EUR/W installed)

3.3.2 Net-billing with feed-in premium

Winning candidates in the Self-Consumption Tender (systems from 100 kW to 1 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

3.4.1 Collective self-consumption (PV systems for several apartments in the same building)

The legal framework surrounding collective self-consumption in France is that of virtual self-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 2020, with a total of 1,3 MW across 45 projects, 650 consumers were involved. The average project involved 13 consumers and 2 generators.

Economic models for self-consumption systems are uncertain, as the competitivity of the self-consumed electricity (up to 0,17 EUR/kWh) is very dependent on consumer electricity costs. In other words, grid parity is reached in certain sectors, and not in others. Moreover, electricity taxes are supported by consumers (up to 0,09 EUR/kWh), surplus electricity does not qualify for FiT and is must be sold at market price.

3.4.2 Solar Community

Solar communities (or citizen investment) continues to grow, with a specialised fund and regional and national networks supporting the inception and development of projects. Groups are clearly interested in collective self-consumption and the creation of renewable and/or citizen energy communities, although the transcription into French law of the latter is not yet complete. With very high environemental and social requirements, solar communitites have demonstrated innovative approaches, for example in the use of raw supports.

Figure 1: Simple logs used as supports for a 250 kW system in Carayac, France - Image credits Céléwatt

3.5 Tenders, auctions & similar schemes

Competitive tenders are the chosen tool for the French government to encourage the development of photovoltaic systems over 100 KW, although projects can be developed outside of the framework in PPA's. Tender selection criteria are 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 urbanised sites are benefited), or even innovation levels, for larger systems. Calls have continued from previous years, with some changes to Tender specifications, for example the maximum size of systems for the self-consumption Tender was increased to 1 MW from 500 kW, and the 30 MW limit was removed for ground-based systems located on wasteland.

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).

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

There were 11 national call for tenders in mainland France over 2020, including the innovation and the Fessenheim tenders, and 4 tenders in the overseas territories.

The 2020 tenders were not affected by the under-subscription of previous years, a result of the decreased volumes called. By reducing the volumes available, competition was maintained and tariffs decreased by about 5 % on the building mounted systems and ground-based system tenders.

Meanwhile, and despite being located in a region with one of France's lowest levels of solar irradiation, family 1 (ground-mounted installations) of the Fessenheim tender resulted in tariffs lower than those in the national tenders, whose laureates are concentrated in sunnier regions.

A number of Tenders had calls open in 2020 in mainland France, as detailed in Table 19 below.

Table 21: : National tender volumes and results 2020

System type and size	Building mounted systems and parking canopies	Building mounted systems	Ground-based systems and parking canopies	Building mounted systems for self-consumption	Innovative solar systems	Energy transition - Fessenheim territory
Individual system size limits	100 kW to 500 kW	500 kW to 8 MW	Ground: 500 kW to 30 MW Canopies: 500 kW to 10 MW	100 kW to 1 MW	500 kW — 6 MW family 1 100 kW — 3 MW family 2	100 kW to 30 MW
Support Mechanism	Call for Tenders 2017–2020	Call for Tenders 2017–2020	Call for Tenders 2017–2020	Call for Tenders** 2017–2021	Call for Tenders 2017–2020	Call for Tenders 2019-2020
Volume	1 175 MW in 11 calls of 75 MW to 150 MW)	1 200 MW in 11 calls of 75 MW to 150 MW	5,78 GW in 9 calls of 330 MW to 850 MW	450 MW in 12 calls of 20 to 50 MW	350 MW in 3 calls of 70/140/140 MW	300 MW in 3 call of 60 to 120 MW
Remuneration type	PPA*	FIP**	FIP**	Self-consumption + bonus on self-consumption + FIP	FIP**	FIP**
Number of Bids	10 and 11th call: 150 selected for 312 MW of bids	10 and 11th call: 152 selected for 194 MW of bids	7, 8 and 9th call: 1 433 selected for 1 992 MW of bids	7, 8 and 9th call: 47 selected for 66 MW of bids	3rd call: 104 selected for 286,2 MW of bids	2nd and 3rd call: 65 selected for 199 MW of bids
Average tendered price (or bonus for self-consumption)	10th call: 94,0 EUR/MWh	10th call: 83,0 EUR/MWh	9th call: 60,4 EUR/MWh	8th call: 13,8 EUR/MWh	3rd call: 85,1 EUR/MWh	2nd call: Family 1 (Ground-based) : 57,6 EUR/MWh

* PPA = Power Purchase Agreement at tendered rate. Contract with an obligated purchaser, the PPA being guaranteed by the French government.

** FIP = Market sales + Additional Remuneration (Feed in premium) 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), with a wide participation across the industry and the agricultural sectors. Whilst the study and recommendation will not be published until mid 2021, the study has been important in bringing stakeholders together to work on a definition and benchmark of current practices. This study may facilitate future “Innovation Tenders” by prviding a common framework for an agrivoltaic section.

3.7 Retroactive measures applied to PV

3.7.1 Renegotiation of tariffs for systems above 250 kW with tariffs from 2006 and 2010

In October the government announced its intention to reduce the financial burden on the state of the high 2006 and 2010 feed-in tariffs by negotiating, on an individual basis, the level of remuneration for systems over 250 kW.

The approximately 850 contracts targeted provide only 5 % of the electricity produced with 2006 and 2010 feed-in tariffs, but represent 30 % of the costs (or between 300 and 400 million euros - as reported by PV – Magazine 29/10/2020).

The Constitutional Council declared it compatible with the constitution, considering that the economic and budgetary benefits, being in the public interest, outweighed the contract signatories right to maintain legal contracts), so long as the capital invested still made a reasonable return. The measure was included in the annual Budget despite being rejected by the Senate, and published in 2021.

Contracts will be renegotiated on an individual basis, with the government goal of limiting the return on capital for these systems to a “reasonable” level, i.e between about 3 % and 4,5 %. At this date, it is not certain that capital used to acquire systems already in operation will be able to benefit from the same measures. Strong parallels have been drawn with retroactive measures applied in other countries in Europe, and local actors are worried about the coming impacts on the ability to finance new installations.

3.8 Indirect policy issues

3.8.1 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 Reunion Isle. The national budget includes a line dedicated to off grid production in rural areas, with a 1 M€ budget in 2020. A change in the conditions of access to this budget line in December widened eligibility to include projects contributing to the energy transition. Normally limited to municipalities with under 2 000 inhabitants, the changes also allow the government to include larger areas with low population density.

3.8.2 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, about 50 large storage facilities are connected to the medium-voltage grid with a capacity of almost 100 MW. 60 % of the cumulated installed capacity was commissioned in 2020.

In the past, there have been competitive calls for tenders with mandatory storage for overseas territories. Family 1 of actual tenders for overseas territories include minimum storage requirements together with potential penalties. The results for the 2020 tenders are not yet published.

Individual / small scale storage

Conditions are not favourable for the development of small-scale storage in France (no subsidies, relatively low electricity consumption costs and winter peak consumption profiles). There are about 11 000 storage facilities in France on residential installations. After a peak of 2 500 new installations per year in 2018 and 2019, the rate of installation decreased to 1 500 in 2020.

Demand Response Measures

Time-of-use electricity rates are offered to consumers in France, with a significant 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.

2020 saw competitive tenders run by the national Transmission Grid Operator, RTE, for demand response measures to provide primary reserve production capacity. These Tenders are an explicit support measure for the development of demand response capacity.

In 2020, 29,8 GWh of demand reduction was registered, through 2 different programs.

3.9 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 2020 for photovoltaic contracts (Feed-in tariffs and premiums) for continental France is 2 936,6 M EUR (source CRÉ). Much of this cost finances contracts signed in 2009 and 2010 – and has led to retroactive measures for these contracts (see above). The estimated future cost of compensation for projects winning competitive tenders in 2020, should they all be built, is 550 million euro over 20 years.

4 INDUSTRY

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

Table 22**: Silicon feedstock, ingot and wafer producer's production information for 2020.**

Manufacturers	Process & technology	Estimated Total Production
Photowatt EDF ENR PWT	mc-Si wafers [MW]	50 MW

Photowatt EDF ENR PWT is a vertically integrated manufacturer, manufacturing its own cells, wafers and modules. Its processes produce multicrystalline and quasi-monocrystalline ingots (Crystal Advanced Process). Its subsidiary, Photowatt Crystal Advanced (in partnership with CSI and ECM Greentech), is specialised in low carbon production of advanced technology silicon ingots and wafers, with a goal of increasing the current 50 MW capacity of the Bourgoin Jallieu (France) site to 400 MW. The COVID crisis in 2020 has impacted the strategic position of EDF with regards to Photowatt, and is likely to result in ownership or operational changes in 2021 or 2022.

Irysolar, part of the ECM Greentech group, 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 (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.

Table 23: PV cell and module production and production capacity information for 2020

Cell/Module manufacturer	Technology (sc-Si, mc-Si, a-Si, CdTe, CIGS)	Production and/or capacity (MW/year)	
		Cell	Module
Wafer-based PV manufactures			
EDF ENR PWT (Photowatt)	sc-Si, mc-Si, qc-Si	10 — 15	10 — 15
Reden Solar			90
Recom Sillia			300
S'tile			15
Systovi			80
Sunpower (Total)			80
VMH Energies			60
Voltec Solar			200
Thin film manufacturers			
ARMOR	OPV	40	40
Dracula Technologies	OPV	/	/
Totals			**Approximately 880 MW**

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

The national industry is relatively small, with several manufacturers targeting specific niche markets, often related to building integration 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.

Several manufacturers have increased their production capacity based on the favourable market visibility given by the national competitive tenders. However, this situation tends now to become less favourable as observed in the heavy decrease of French modules' share in the results of 2019 and 2020 competitive tenders.

Small-scale producers of low carbon footprint modules dedicated to the national market, where low carbon footprint modules receive a bonus are listed below:

- **Recom Sillia**'s Lannion site production has a 300 MW/year capacity;
- **Sunpower (Total Group subsidiary)** has two factories in France: Tenesol Technologies in Toulouse and SunPower Manufacturing de Vernejoul, Moselle, and manufactures modules from PV laminates. The modules use single-crystal silicon back-contact cells manufactured by overseas Sunpower factories, with industry high

performances of up to 24 %. The two factories have a production capability around 40 MW each one;
- **Voltec Solar** assembles modules on their Alsace site, its production capacity is 200 MW/year;
- **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;
- **VMH Energies** production site is located in Châtellerault near Poitiers. Its production capacity is 60 MW per year;
- **SCNASolar** has been liquidated in 2018. Its photovoltaic activity has been undertaken by VMH Energies. The production site of SCNA Solar located in Tourouvre has been closed.

Integrated cells and modules manufacturer:

Photowatt/EDF ENR PWT's Bourgoin Jailleu site, rebranded the Photowatt Lab, has a module production capacity of 10 MW to 15 MW per year. Photowatt/EDF ENR PWT now concentrates on research and development to "foster the emergence of new technological solutions" and test them in pre-industrial conditions. Photowatt Crystal Advanced, a Photowatt's subsidiary, also produces photovoltaic cells with an estimated production capacity of 10 MW/year.

Other markets: Photovoltaic tiled roofs, photovoltaic thin films and aero-voltaic modules:

- **Systovi** assembles polycrystalline and monocrystalline modules. It mainly manufactures PV/thermal hybrid modules (hot air). Its manufacturing facilities are located at Carquefou, close to Nantes. The company, whose turnover is mainly realised on the international market is owned by the Cetih group;
- **S'Tile** develops a 15 MW pilot line where their proprietary "i-Cells®" are assembled into modules since early 2017. The company develops a line of modules from 25 W to 200 W with customised formats for BIPV or off grid applications, such as integration into streetlights. They have a small range of standardised modules targeting high end building integration clients;
- **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 m^2 / 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. 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.

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

The Norwegian manufacturer REC is planning to build a heterojunction module factory in France with a capacity of 2 GW/year (in 2022) then 4 GW/year (in 2025). This production site, planned in Moselle, could produce the equivalent of France's needs to meet the Energy Programme Decree.

4.3 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 to overseas territories.

Supporting structures

France has, for the past 10 years, strongly encouraged fully building integrated PV, with preferential feed-in tariffs and access to Tenders, only being phased out over 2017/2018.

Photovoltaics, and their building integration or on-roof installation accessories, are not considered “traditional building techniques” in France, and as such require individual material and installation procedure certification (Avis Technique – Technical Advice or Enquête Technique Nouvelle - Assessment of New Techniques) before being accepted as viable solutions by most insurers.

Obtaining a Technical Advice is a lengthy process, and return on investment is not guaranteed due to the size of the market. Once the supporting system is certified through this process, the Products Prevention Commission managed by the AQC (Construction Quality Agency), composed of building professionals and insurers, decides if it can appear on their “Green List” or if the product family remains “under observation”. This list is regularly updated, according to insurance claims level, and is a reference for most PV insurers. Some roof mounting kits were certified in 2020, giving installers the possibility to propose this kind of systems, while other manufacturers still struggle to have their products certified. One of the consequences is that installers have difficulty qualifying for the 10-year building liability warranty, mandatory in France, especially those that are new to the market.

Some manufacturers that had previously invested in building-integration systems have now developed a wider range of supporting structures, and the domestic market is seeing, in particular, carport solutions for residential and commercial sites. Moreover, BAPV solutions are multiplying for the residential market of tiled roofs. IRFTS and GSE Integration are the two main integration support manufacturers for residential market.

Manufacturers of on-roof systems for industrial metallic roofs and bituminous or polymer roofs still remain since 2011, as Dome Solar, Solapro, Arcelor or Soprasolar.

France photovoltaic sector relies strongly on imports, particularly for commercial and industrial systems. Imports mainly come from other European countries, in particular Germany.

5 PV IN THE ECONOMY

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

5.1 Labour places

Table 24: Estimated PV-related full-time labour places in 2020

Market category	Number of full-time labour places
Research and development (not including companies)	300
Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D	700
Distributors of PV products and installations	5 000*
Other	2 500*
Total	**8 500**

Sources: Etude ADEME “marché et emplois des ENR en France” (2019), Évaluation et analyse de la contribution des EnR à l’économie de la France et des territoires 2020, SER and Hespul estimates (*).

If jobs related to manufacturing of photovoltaic equipment, R&D or installation of PV system are stagnating, those dedicated to project development, studies and operations are growing.

Last available data concern the year 2016. They have been completed and updated based on market evolution in 2020. More recent studies indicate a total of 17 000 direct and indirect jobs without providing a breakdown between the different market segments.

The French government maintained employment through the COVID-19 lockdown with strong employment subsidies. In the subsequent reopening, anecdotal evidence indicated strong recruitment in the photovoltaics sector (development and site-works) but it is too early to tell if this will be maintained through 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 2020 (below) has been estimated based on 2020 trending prices and extrapolated official 2020 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. An EY study commissioned by the French Renewable Energy Trade Association estimates the added value of the sector at 1.5 billion euros in 2020, but does not give a breakdown of the wealth created by power segment. EY's estimate is the result of macro-economic modelling, based on an input-output table (IOT) considering imports and exports for each segment of the value chain. Their estimate is likely to be more accurate than the one presented below, however below remains relevant as a first approach and is sufficient to compare with other PVPS countries.

The following table represents the value of investments in PV systems.

Table 25: Rough estimation of the value of the PV business in 2020 (VAT is excluded)

Sub-market	Capacity installed in 2020 [MW]	Average price [€/W]	Value M EUR
Off-grid			
Residential < 3 kW	49	2,4	118
Residential < 9 kW	61	1,85	113
Commercial < 100 kW	341	1,15	392
Commercial < 250 kW	62	0,85	53
Industrial > 250 kW	24	0,85	20
Grid-connected distributed	**537**	**1,3**	**696**
Grid-connected centralized	**460**	**0,7**	**322**
Estimated Value of PV investments in 2020			**1 000 to 1 200****

SOURCE: SDES, Observ'ER Baromètre Électrique 2020, France Terre Solaire Bilan 2020 *estimate HESPUL, Marches et emplois liés à l’efficacité énergétique et aux énergies renouvelables 2019 ADEME, Évaluation et analyse de la contribution des EnR à l’économie de la France et des territoires 2020 SER, Coûts des énergies renouvelables et de récupération 2019 ADEME.

** 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 EDF, (the state holds over 80 % of EDF share capital) 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 (the state is the majority owner with over 80 % of share capital), 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 different 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) are all active in France. EDF Store & Forecast provides software solutions for piloting renewables and storage. 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 installed over 3,9 GW worldwide and owns roughly half this capacity - EDF also has near 3,9 GW under construction.

ENGIE is a gas utility also present in the development and generation of electricity capacity - and has the biggest solar portfolio in France at around 1 GW.

The public utility Soregies, the largest of Frances public utilities, serves a population of approximately 150 000. Its subsidiary company Sergies is owner-operator of 78 MW of photovoltaics and continues to develop large scale operations, including floating systems, with the goal of reaching 100 % renewables by 2035.

6.3 Interest from municipalities and local governments

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 the projects to facilitate grid integration), and facilitating citizen investment and grid integration. The municipal elections of 2020 resulted in historically unprecedented scores for Greens candidates, winning six large cities (up from one) including Lyon and Bordeaux, where photovoltaics are part of the cities priorities.

The keen interest and ambitions of local government was a strong driver for the government to remove two major barriers, as reported in last year's National Survey Report:

- replacing competitive tenders in the 100 kW to 500 kW segment with open access feed in tariffs, more compatible with public tendering requirements and with reduced risks;
- removing barriers in the current framework that considered that all installations within a 100 m radius developed concurrently were to be considered as a single system – and hence impacting the accessibility of feed in tariffs.

The much-awaited new feed in tariffs to be published in 2021 will resolve these two main barriers, facilitating the deployment of photovoltaics on local government infrastructure.

7 HIGHLIGHTS AND PROSPECTS

7.1 Highlights

The new Energy Program Decree (PPE) for photovoltaics, published in April 2020, has a 2023 target of 20,6 GW and a 2028 target of 35,6 GW to 44,5 GW. The PPE maintains and strengthens the priority given to the development of less costly ground based and parking canopy systems. In 2020, national photovoltaic capacity grew by 973 MW, slightly more than the 966 MW in 2018 (862 MW in 2017), for a cumulative capacity of 10 860 MW for grid connected installations. The annual installation rate has stagnated between 0,6 and 1 GW since 2012.

Since 2017, the stock of projects under appraisal has increased significantly, from 2 GW to 9 GW in 2020. The majority of this stock comes from the wave of tenders launched in 2017 - the annual volume has tripled compared to previous years. The time between the publication of the winners and commissioning is particularly high in France, probably more than 3 years or 4 years for this type of project. This would partly explain the fact that the rate of installation has stagnated at 1 GW/year since 2017 despite the very strong increase in the volume of tender winners, which is between 2 GW/year and 3 GW/year.

7.2 Prospects

The governments recognition of the efforts necessary to meet the new Energy Program Decree (PPE) for photovoltaics (2023 target of 20,6 GW and a 2028 target of 35,6 GW to 44,5 GW) has facilitated the project for increasing the maximum system size for open access feed in tariffs to 500 kW, and increased volumes to be called in competitive tenders. All in all, the government hopes for roughly 3 GW per year.

However, given the rather long lead times in France (18 months to 48 months), and the fact that the texts were still unpublished in May 2021, it is unlikely that the effects of these be felt in commissioned volumes until, at earliest, the 2nd quarter of 2022. Similarly, the mandatory solar/living roofs for building over 1 000 m^2 of ground surface is unlikely to see much volume commissioned before 2022, or even 2023, when considering design and permitting delays.

Consequently, 2021 should see between 1,5 GW and 2 GW commissioned.

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