Technology Collaboration Programme
by iea

International Energy Agency
Photovoltaic Power Systems Programme

Task 1 Strategic PV Analysis and Outreach

PVPS

National Survey Report of PV Power Applications in FRANCE

2019

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 2019. Information from this document will be used as input to the annual Trends in photovoltaic applications report.

Authors

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- **Data:** Service de la donnée et des études statistiques, Commissariat au Développement Durable, the Ministry for the Ecological and Inclusive Transition, Commission de Régulation de l'Energie, Enedis Open Data, others.
- **Analysis:** Damien Salel and Frédéric Delpit – HESPUL

COVER PICTURE

17 MW floating PV system on former quarry, Piolenc

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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.

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- 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, 2018, 2019 and 2020)

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 2019 statistics if the PV modules were installed and connected to the grid between 1 January and 31 December 2019, 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 DC power of photovoltaic fields, as eligibility for Feed-in Tariffs and Tender support mechanisms is conditioned on 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 2019 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 have been installed in overseas territories (Guiana, etc.) or in mainland mountainous areas.

The progressive shift from feed-in to partial self-consumption for residential systems (under 36 kW), initially observed in 2017, was confirmed in 2019. Indeed, in 2019, self-consumption amounted to more than 65**%** of new grid connection requests (in number of installations), compared to 55% in 2018 and around 30% in 2017 for this segment. Systems under 36 kW represented approximately 12 % of installed PV volumes in 2019.

Small commercial systems volumes for the 36 kW-100 kW segment has increased from 16 % of installed capacity in 2018 to more than 22 % in 2019. This represented the majority of installed capacity (in terms of power) on commercial buildings in 2019.

Commercial systems over 100 kW and below 250 kW represented nearly 100 MW in 2019, or over 10% 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 42% of new capacity (406 MW in 2019).

1.2 Total photovoltaic power installed

Cumulative PV installed capacity as of the end of 2019 reached 9 934 MW (DC – Direct Current). Cumulative PV installed capacity by application is 30 MW for off-grid and 9 904 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.

For the purposes of this report, we have considered the following hypotheses for 2019 data:

Grid connected distributed (decentralized) systems:

- Residential: up to 9 kW no datas are available concerning the split BIPV /BAPV as feed-in tariff for BIPV has been stopped in 2018. Therefore, the split BIPV/BAPV has been extrapolated from CRE (Commission de Régulation de l'Energie – Energy Regulator) grid connection request data and SDES grid connection data;
- 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 the Observ'ER Atlas of megawatt systems and grid connection data published by Enedis;
- Utility scale systems: all systems over 10MW.

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 2019

		Installed PV capacity in 2019 [MW]	AC or DC
PV capacity	Off-grid	/	DC
	Decentralized	431	DC
	Centralized	535	DC
	Total	966	DC

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

Table 2: PV power installed during calendar year 2019

			Installed PV capacity in 2019 [MW]	Installed PV capacity in 2019 [MW]	AC or DC
Grid-connected	BAPV	Residential	454	93*	DC
		Commercial		337	DC
		Industrial		24*	DC
	BIPV	Residential	No data available as feed-in tariff bonus for BIPV has been stopped		DC
		Commercial			DC
		Industrial			DC
	Utility-scale	Ground-mounted	512	494*	DC
		Floating		17*	DC
		Agricultural		< 1*	DC
Off-grid		Residential	No data available		DC
		Other			DC
		Hybrid systems			DC
Total			966		DC

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

Table 3: Data collection process

Reported in AC or DC?	All power data is given in DC power.
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.
Link to official statistics	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.

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]
1992				1,8
1993				2,1
1994				2,4
1995				2,9
1996				4,4
1997				6,1
1998				7,6
1999				9,1
2000				11,3
2001				13,9
2002				17,2
2003				21,1
2004				24,2
2005				25,9
2006				37,5
2007	22,5	53	0	75,5
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 (revised)	8 961,15
2019	30,15*	5 796	4 108	9 934,15

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><th></th><th colspan="3">2019</th></tr>
<tr><td>Number of PV systems in operation in your country</td><td colspan="3"><table>
<tr><th>Peak Power range</th><th>Installations (number)</th><th>Power (MW)</th></tr>
<tr><td>0 – 3 kW</td><td>316 171</td><td>853</td></tr>
<tr><td>3 kW–9 kW</td><td>92 113</td><td>582</td></tr>
<tr><td>9 kW–36 kW</td><td>20 117</td><td>495</td></tr>
<tr><td>36 kW–100 kW</td><td>17 184</td><td>1 424</td></tr>
<tr><td>100 kW–250 kW</td><td>7 096</td><td>1 280</td></tr>
<tr><td>> 250 kW</td><td>1 713</td><td>5 270</td></tr>
<tr><td>Total</td><td>454 394</td><td>9 904</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 colspan="3">0 (estimated)</td></tr>
<tr><td>Capacity of repowered PV systems during the year [MW]</td><td colspan="3">0 to 10 (estimated)</td></tr>
<tr><td>Total capacity connected to the low voltage distribution grid [MW]</td><td colspan="3">452 681 systems for 4 634 MW</td></tr>
<tr><td>Total capacity connected to the medium voltage distribution grid [MW]</td><td colspan="3">1 637 systems for 4 626 MW</td></tr>
<tr><td>Total capacity connected to the high voltage transmission grid [MW]</td><td colspan="3">76 systems for 644 MW</td></tr>
</table>

Table 6: PV power and the broader national energy market

	2018	2019
Total power generation capacities [GW]	Total: 132,889 GW of which - Nuclear: 63,130 GW; - Fossil fuel: 18,588 GW; RES: 51,171 GW (see below)	Total: 135,3 GW of which - Nuclear: 63,130 GW; - Fossil fuel: 18,589 GW; RES: 53,581 GW (see below)
Total renewable power generation capacities (including hydropower) [GW]	- PV*: 8,527 GW (6,4%); - Hydro: 25,510 GW; - Wind: 15,108 GW; - Other RES: 2,026 GW	- PV*: 9,435 GW (7 %); - Hydro: 25,557 GW; - Wind: 16,494 GW; - Other RES: 2,095 GW
Total electricity demand [TWh]	478 TWh	473 TWh
Total energy demand [MToe]	154,3 Mtoe**	152,23 Mtoe**
New power generation capacities installed in 2019 [GW]	Total: 2,054 GW of which • Gas: +0,218 GW; • Coal: 0 GW; • Diesel: -0,657 GW; • Nuclear: 0 GW; PV and other RES: +2,493 GW (see below)	Total: 2,295 GW of which • Gas: +0,044 GW; • Coal: 0 GW; • Diesel: -0,096 GW; • Nuclear: 0 GW; PV and other RES: +2,346 GW (see below)
New renewable power generation capacities installed in 2019 (including hydropower) [GW]	• PV*: + 0,873 GW; • Wind: + 1,558 GW; • Hydro: - 0,011 GW; • Other RES: + 0,073 GW	• PV*: + 0,89 GW; • Wind: + 1,36 GW; • Hydro: + 0,021 GW; • Other RES: + 0,075 GW
Estimated total PV electricity production (including self-consumed PV electricity) [TWh]	PV: 10,2 TWh	PV: 11,6 TWh
Total PV electricity production as a % of total electricity consumption	2,1%	2,2%

2018 : RTE France Electricity Report 2018.

2019 : RTE France Electricity Report 2019. *RTE provisional PV figures differ from those of SDES, Tableau de bord : solaire photovoltaïque en Q4 2019.

** 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: 3 818 Overseas: 212		www.consuel.com Consuel Rapport d'activité 2018
	Other sites	Mainland France: 31 Overseas: 9		
Residential Heat Pumps	Mono and multi-split reversible heat pumps	728 433	4 245 831	www.uniclima.fr Uniclima : Bilan 2019 et perspectives 2020 du génie climatique
	Thermodynamic domestic water heater	116 929	607 451	
	Total since 2012	845 362	4 853 282	
Electric cars	Electric cars	42 763	166 711	www.avere-france.org AVERE: Bilan 2019
	Lightweight utility vehicles	7 958	48 337	
	Hybrid rechargeable cars	18 582	57 316	
	Total since 2010	69 003	272 364	

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

The Energy Regulator, CRE, has published statistical data based on the business plans submitted by candidates in the competitive Tenders from 2011 to 2018. Note that there may be slight differences between these declared prices at the moment of the tender submission, and the final prices under construction 2 years later.

For more information, the CRE statistical analysis of the competitive tender candidate projects can be obtained on the CRE website: https://www.cre.fr/content/download/20543/261330.

2.1 Module prices

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	2011	2012	2013	2014	2015	2016	2017	2018	2019
Average module price (all technologies) for systems in Tenders	2	1,5	/	0,7	0,6	0,7	/	/	
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, 13% polycrystalline silicon and 27% thin film technologies							0,55	0,4	0,4

SOURCE : CRE “Coûts et rentabilités du grand photovoltaïque en métropole continentale”, pvXchange and Hespul estimate.

2.2 System prices

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

Category/Size	Typical applications and brief details	Current prices [€/W]
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.	2,3 – 3
Residential BAPV 5-10 kW	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity to grid-connected households. Typically roof-mounted systems on villas and single-family homes.	1,7 – 2,1
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 - 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.	1 - 1,2
Industrial BAPV >250 kW	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity to grid-connected industrial buildings, warehouses, etc.	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 electricity for sale.	0,8 - 1,0
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.	0,65 - 0,85
Large centralized PV >20 MW	Grid-connected, ground-mounted, centralized PV systems that work as central power station. The electricity generated in this type of facility is not tied to a specific customer and the purpose is to produce electricity for sale.	No data
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.	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.	1 – 1,1

for 2017 Trends: estimation HESPUL, sources Hespul/In Sun We Trust/Observ'ER

for 2018: FiT systems: estimation HESPUL. Tenders source CRE “Coûts et rentabilités du grand photovoltaïque en métropole continentale”.

for 2019 : 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 [€/W]	**Small commercial BAPV** Grid-connected, roof-mounted, distributed PV systems 10-100 kW [€/W]	**Large commercial BAPV** Grid-connected, roof-mounted, distributed PV systems 100-250 kW [€/W]	**Small centralized PV** Grid-connected, ground-mounted, centralized PV systems 10-20 MW [€/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

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, 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 CRE study (see above) concerned the turnkey PV system prices for systems over 100 kW, by segment. This section presents the breakdown of these costs for the same segment.

Table 11: Cost breakdown for a grid-connected, ground-mounted, centralized PV systems of > 10 MW

Cost category	Average [€/W]
Hardware	
Module	0,35
Inverter	0,06
Mounting material	
Other electronics (cables, etc.), including installation	0,2
Subtotal Hardware	**0,6**
Soft costs	
Planning	
Installation work	(included in Other Hardware costs)
Shipping and travel expenses to customer	
Customer acquisition	0,03
Permits and commissioning (i.e. cost for electrician, etc.)	0,07
Project margin	-
Subtotal Soft costs	**0,1**
Grid connection	0,1
Total (excluding VAT)	**0,8**
Average VAT	20%

SOURCE : CRE “Coûts et rentabilités du grand photovoltaïque en métropole continentale”.

Etude ADEME « Coûts des énergies renouvelables et de récupération en France ».

2.4 Financial Parameters and specific financing programs

Table 12: PV financing information in 2019

Different market segments	Loan rate [%]
Average rate of loans–residential installations	4% - 7% over 12 years
Average rate of loans–commercial installations	2% over 18 years
Average rate of loans - capital–industrial and ground-mounted installations	2% 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.

2.5 Specific investments programs

Table 13: 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. 67% of projects in the competitive tenders were eligible for the crowdfunding bonus.
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).

There is a wide range of financial instruments available in France for photovoltaics projects, including 19 funds (on 31/12/2019) that obtained by the Greenfin (formerly label TEEC) 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.

In 2019, 26 fund raisings in renewable energies have been signed off for a total amount of 491 M€, thus 36% lower compared to 2018. The biggest one has been realized by Voltalia, for an

amount of 376 M€. These operations include capital investment, business angels, crowdfunding and floating on the stock exchange.

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, generally for up to 80% of capital costs—the programme "France Energie Renouvelables II", signed in December 2017 has a total EIB contribution of 1 125 MEUR. The programme runs through national banking partners and is available to both private and public-sector entities.

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. According to the BEI, new financial institutions not involved in the 2017 project are expressing strong interest in developing similar partnerships.

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.

Some French developers carried out fundraising in 2019, as APEX Energie (15 M€), Corsica Sole (20 M€), Technique Solaire (54 M€)…

Community solar (citizen investment)

Citizen investment is mobilised through specific citizen RES funds and crowd-funding platforms—financing both equity and debt. Launched in January 2018, EnRciT finances the development phase of large-scale citizen investment projects (community solar) with a 10 M EUR envelope available for 150 projects over the next 10 years. In 2019, EnRciT has been involved in the financing of RES project development representing around 20 MW, including 5 MW of photovoltaics.

Crowdfunding

Crowdfunding of projects linked with environment or RES increased significantly all over 2019 (+77%). Whilst overall crowdfunding represents less than 5% for all RES project finance, for PV building mounted photovoltaics the proportion raised to 25% and up to 40% for systems above 500 kW.

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 124: Country information

Retail electricity prices for a household	Time of use contracts available. Eurostat Band DC (2 500 kWh < consumption < 5 000 kWh) • 191,35 €/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): • 129,10 €/MWh excluding VAT and other recoverable taxes and levies: • 154,35 €/MWh all taxes and levies included. Eurostat Band IC (500 MWh < consumption < 2 000 MWh): • 98,70 €/MWh excluding VAT and other recoverable taxes and levies: • 118,04 €/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): • 81,2 €/MWh excluding VAT and other recoverable taxes and levies; • 96,9 €/MWh all taxes and levies included.			
Population at the end of 2019	67 063 703			
Country size [km^2]	543,965 km^2 EU, Corsica included			
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)			
Name and market share of major electric utilities		Electricity production [%]	Share of grid Subscribers [%]	Number of retail customers [%]
	EDF	Approx. 80%	96%	76%
	Engie		<1%	10%
	Total Direct Energie			4%
	E.On			

SOURCE: INSEE, CRE, Eurostat [nrg_pc_204] and (nrg_pc_205) 2019S2

3 POLICY FRAMEWORK

Table 15: Summary of PV support measures

Category	Residential		Commercial + Industrial		Centralized	
Measures in 2019	**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)	Yes, (competitive Tenders for Fessenheim territory)	Yes, (competitive Tenders)	Yes, (competitive Tenders 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	-	-	-
Commercial bank activities e.g. green loans	-	-	-	-	Yes	Yes
Activities of electricity utility businesses	-	-	-	-	-	-
Sustainable building requirements	Yes	-	Yes	-	-	-
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. French 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 16a - 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	185,7
Ta (no self-consumption)	3 kW to 9 kW	157,9
Tb (no self-consumption)	9 kW to 36 kW	120,7
Tb (no self-consumption)	36 kW to 100 kW	109,4
Call for Tenders	100 kW - 500 kW Building applied systems	Last 2019 average selling price (average EUR/MWh) 97,5*

* for projects that will be built in 2021

Table 16b: Feed-in Tariff and Tender remuneration levels–Overseas France

Tariff category	Power of PV installation	Tariff Q4 2019 (EUR/MWh)
Tariff base		9,73
Sample system in Guadeloupe	2 kW	214,8
Sample system in Corsica	8 kW	168,4
Sample system in Réunion	50 kW	149,7
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	= 9,73 x 1,35 x location factor = 9,73 x 1,2 x location factor = 9,73 x 1,1 x location factor = 9,73 x 1x location factor = 0
Location factor		
Guadeloupe & Martinique Corsica Réunion French Guiana Mayotte	17 15 16 18 19	= 9,73 x 17 x power factor = 9,73 x 15 x power factor = 9,73 x 16 x power factor = 9,73 x 18 x power factor = 9,73 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.

3.2.1 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.

Eight competitive Tenders were held in 2019 either in mainland France and overseas, for a total volume of 2,15 GW: for building applied, for ground-based systems, for self-consumption systems, for innovative systems, one for Fessenheim territory related to a nuclear power plant shutdown and two for overseas territories (see section 3.4).

3.2.2 BIPV development measures

The feed-in-tariff bonus for small building integrated systems was finally phased out in October 2018, marking the end of more than a decade of targeted support mechanisms for building integration PV (BIPV).

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.

Future energy regulation for buildings called RE2020, expected to come into force in 2021, has been extensively discussed with building sector representatives, based on E+C- (Energy+ / Carbon-) experimentation label results. E+C- experimentation label was launched in 2016 with the aim to experiment building construction including not only energy consumption criteria but also greenhouse gas emission criteria. Thus, the future regulation should include a new set of criteria on energy and carbon, also applied to photovoltaic 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 13: Summary of self-consumption regulations for small private PV systems in 2019

PV self-consumption	1	Right to self-consume	Individual self-consumption: the PV producer can be the consumer or a third-party owner. Participation in a collective self-consumption operation is limited to 2 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). In any case, producer(s) and consumers(s) must be linked through a common legal entity. Virtual net-metering (virtual battery storage): the consumer must be the same as the PV producer.
	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,	Systems with total self-consumption pay no connection or annual grid access costs.

		Distribution grids & Renewable Levies	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	Metering timeslots are 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 2 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). Compensation on a ½ hour time-step. Virtual net-metering available through virtual battery storage offers.
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…)	Electrical 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 producer sell directly to a consumer without the producer 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 were offered on the market in 2018,

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

Table 18: 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 (+0,39 EUR/W installed)
Pa (net-billing)	3 kW to 9 kW	100 (+ 0,29 EUR/W installed)
Pb (net-billing)	9 kW to 36 kW	60 (+ 0,18 EUR/W installed)
Pb (net-billing)	36 kW to 100 kW	60 (+ 0,09 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) will 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

The legal framework surrounding collective self-consumption in France is that of virtual self-consumption within a building or a 2 km geographical perimeter. In the case where producers and consumers are gathered in the same building, PV installation can be connected to the medium voltage grid. In other cases , installations shall be connected to the low voltage grid and shall not sum to more than 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 share of PV production attributed to each consumer selected for the operation, and an updated list of registered members of the operation.

By the end of 2019, around 20 projects were operational (more than 300 consumers), although approximately 100 were expected to be in operation by late 2020.

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) and surplus electricity does not qualify for FiT and is bound to be sold at market price, both elements lowering economic attractiveness of these operations.

3.4.2 Solar Community

Solar Community is developed through citizen investment, generally built on access to feed-in tariffs. However, community groups have clearly stated their interest for self-consumption schemes, although the economic viability has not yet led to installations. The main non-profit organisations promote community and citizen Tenders, auctions & similar schemes.

European directive Renewable Energies from 11 December 2018 has introduced the concept of renewable energy communities in European law. Transcription in French law is on-going.

3.5 Competitive tenders

Competitive tenders are the chosen tool for the French government to encourage the development of photovoltaic systems over 100 KW. 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 8 national call for tenders over 2019, including the innovation and the Fessenheim tenders.

With the aim to rectify repeated under-subscriptions on self-consumption competitive tender, the target has been decreased from 50 to 25 MW per subscription period. 2019 also saw under-subscriptions on competitive tenders for buildings. The tariffs of building-mounted systems and ground-based systems tenders have respectively increased of 20% and 10% compared to 2018 ones. Meanwhile the cost of equipment has stagnated and even decreased.

Meanwhile and even if located in a region with less solar irradiation than other ones on average, family 1 (ground-mounted installations) of Fessenheim tender has reached tariffs as high as the ones of the national tender whose laureates are concentrated in sunnier regions.

A number of Tenders had calls open in 2019, as detailed in Table 19 below.

Table 19: National tender volumes and results 2019

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 of 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	100 kW to 3 MW	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** 2017–2020	Call for Tenders 2017–2020	Call for Tenders 2019-2020
Volume	1 175 MW in 10 calls of 75 MW to 150 MW)	1 200 MW in 10 calls of 75 MW to 150 MW	5,77 GW in 8 calls of 500 MW to 1 000 MW	450 MW in 12 calls of 25 to 50 MW	350 MW in 3 calls of 70 to 140 MW	300 MW in 3 calls of 60 to 120 MW
Remuneration type	PPA***	FIP****	FIP	Self-consumption + bonus on self-consumption + FIP	FIP	FIP
Number of Bids	7, 8 and 9th call: 212,6 for 291,9 MW of bids (undersubscribed)	7,8 and 9th call: 218,6 for 302 MW of bids (undersubscribed)	5 and 6th call: 1 713 for 2 069 MW of bids	5 and 6th call: 40,3 for 50,7 MW of bids (undersubscribed)	2nd call: 104 for 286,2 MW of bids	1st call: 65 for 199 MW of bids
Average tendered price (or bonus for self-consumption)	7, 8 and 9th call: 97,6 EUR/MWh	7,8 and 9th call: 88,9 EUR/MWh	5 and 6th call: 63,2 EUR/MWh	5 and 6th call: 20,6 EUR/MWh	2nd call: 82,8 EUR/MWh	1st call: 66,05 EUR/MWh

** Call for Tender is not limited to photovoltaics systems; other RES technologies are eligible.

*** PPA = Power Purchase Agreement at tendered rate. Contract with an obliged 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

One call for tender is dedicated to innovative installations. This includes among others agrivoltaism installations.

In 2019, 12 projects representing 25 MW were laureates of the second period of this competitive tenders in the category agrivoltaism.

2019 saw the inauguration of the biggest floating photovoltaic installation in Europe, located in Piolenc – southeast of France - with a peak power of 17 MWp.

3.7 Indirect policy issues

3.7.1 Rural electrification measures

Rural electrification in France is primarily concentrated in overseas territories and isolated alpine activities. 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 2019.

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 the residential sector, despite the low economic returns.

Large scale storage

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. Thirty-eight projects for a capacity of 54,8 MWp including storage have been awarded in 2019.

Individual / small scale storage

Whilst conditions are not favourable for the development of small-scale storage in France (relatively low electricity consumption costs and winter peak consumption profiles), there has been a slow uptake. There are no specific support programs in place.

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.

2019 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 2019, 29,8 GWh of demand reduction was registered, through 2 different programs.

3.7.1 Support for electric vehicles (and VIPV)

A national subsidy of 4 000 EUR was made available for the purchase of electric cars. However, plug-in hybrid cars are no longer eligible for the subsidy scheme. Electric trucks and buses were eligible for a 4 000 EUR subsidy. An additional subsidy of 2 500 EUR was available if the purchase of an electric car was accompanied by the destruction of an older

model petrol- or diesel-powered car. These subsidies were coupled with tax breaks such as over-depreciation and an exoneration of the company vehicle tax for companies purchasing electric cars or trucks.

A number of local authorities (including Paris) have subsidies for the purchase of electric vehicles including bicycles, scooters and private or commercial use cars. Many local authorities that normally collect a one-off tax on a vehicle first registration have waived the tax for electric vehicles.

A 30% tax credit on the costs of installing a charge station in a single or multiple-occupancy dwelling, plus direct subsidies from a number of local authorities was continued through 2019.

3.7.2 Curtailment policies

In France's ZNI (Non inter-connected zones, i.e. the French Antilles, French Guiana, Corsica and other small islands), law of 23rd of april 2008 (technical prescriptions for MV/LV grid connection of electrical production installations) limits the production from intermittent sources to a maximum of 30% of consumption at any time. This maximum is guaranteed by disconnecting variable renewable production sources (solar, wind…) on a last connected / first disconnected basis. EDF, who operates the grid in these zones, evaluates the number of hours they expect new projects to be disconnected from the grid to give new projects enough visibility to go ahead (or abandon).

3.7.3 Other support measures

France is a founding member, with India, of the Alliance Solaire Internationale (ASI). The ASI's primary goal is to massively reduce the costs of solar energy to accelerate the deployment of solar energy in countries between the tropics, through the creation of a "common market" for solar. The second assembly of the Alliance was held in 2019, when the government announced having already engaged 800 M€ of a promised 1 billion euros by 2022.

The Energy and Climate Law voted on November 8th, 2019 introduced changes in urbanism rules. Ground-mounted PV systems along main roads are authorized, even in the 100 meter strip that cannot be usually build on or on service areas. Moreover, the law made compulsory the installation of renewable energies or green roofing on at least 30% of the roof surface of new commercial or industrial building, for which solar PV is an attractive solution.

3.8 Financing and cost of support measures

Operator remuneration (through Feed-in PPA, 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 2019 for photovoltaic contracts (Feed-in tariffs and premiums) is 2 961,7 M EUR (source CRÉ).

3.9 Power Purchase Agreement : Free of policy

PPA (Power Purchase Agreements) at market prices (without guarantees or fixed rates from French government) are being developed. In 2019, such agreements have been contracted for an amount of 176 MW. The average duration of contracted PPA's is 25 years.

The main PPA signed off in 2019 accounts for 143 MW between SNCF (French Railway company) and Voltalia.

4 INDUSTRY

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

Table 20: Silicon feedstock, ingot and wafer producer's production information for 2018.

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 produced 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.

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 in a country report if the encapsulation takes place in that country.

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

Table 21: PV cell and module production and production capacity information for 2019.

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			65

Recom Sillia			300
Systovi			40
Sunpower (Total)			80
VMH Energies			60
Voltec Solar			200
Thin film manufacturers			
ARMOR	OPV	40	40
Dracula Technologies	OPV	/	/
Totals			**Approximately 740 MW**

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 before 2019. However, this situation tends now to become less favourable as observed in the heavy decrease of French modules' share in the results of 2019 competitive tenders.

Small-scale producers of low-carbone modules dedicated to national market are listed below:

- **Recom Sillia**'s Lannion site production increased its capacity from 60 to 300 MW/year in 2019;
- **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 increased from 70 to 200 MW/year. Its turnover approximately reached 30 M€ in 2019 with a production dedicated to national market;
- **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** knew a growth of 40% of its turnover between 2017 and 2018 to reach 16 M€ in 2018. Almost 100% is realized on the national market. Their production capacity is of 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. A partnership agreement was signed with the UNESCO for the deployment of Armor products to school children in unelectrified areas of Togo. The company took control of German Opvius in 2019, also specialized in organic PV;
- **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;
- **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).

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 2019, 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.

The AQC published a study on electrical risks detection, a follow-up to the one made last year on the description of electrical risks.

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. GSE exports 10% of its production while IRFTS dedicates only to national 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

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

Last available data concern the year 2016. They have been completed and updated based on market evolution in 2019.

Sources : Etude ADEME « marché et emplois des ENR en France » (2019) and Hespul estimate (*).

Table 22: Estimated PV-related full-time labour places in 2019

Market category	Number of full-time labour jobs
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	100*
System and installation companies	4 500
Electricity utility businesses and government	/
Other	2 500*
Research and development (not including companies)	500*
Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D	40
Total	**Approximately 8 500**

5.2 Business value

Investments and turnover are studied for ADEME every two years in the study “Marches et emplois liés à l’efficacité énergétique et aux énergies renouvelables“.

The market value for 2019 (below) has been estimated based on 2019 trending prices and extrapolated official 2019 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 PV systems.

Table 23: Rough estimation of the value of the PV business in 2019 (VAT is excluded)

Sub-market	Capacity installed in 2019 [MW]	Average price [€/W]	Value M EUR	M EUR (provisional)
Off-grid				/
Residential < 3 kW	45	2,5	113	
Residential < 9 kW	48	1,8	86	
Commercial < 100 kW	238	1,2	286	
Commercial < 250 kW	99	1,1	109	
Industrial > 250 kW	24	1,1	26	
Grid-connected distributed	**454**	**1,4**		**600**
Grid-connected centralized	**512**	**0,8**		**400**
Estimated Value of PV investments in 2019				**900 to 1 100****

SOURCE : SDES, Observ'ER Baromètre Electrique 2019, France Terre Solaire Bilan 2019 *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

France's electricity industry is highly concentrated but nominally not vertically integrated. To conform to European Directives, generation, transmission and distribution are managed by different legal entities: the national transmission grid (HVB) is managed by RTE, an EDF subsidiary, and much of the national distribution grid (95%) is managed by Enedis (ex-ERDF), another EDF subsidiary. These missions are run as "delegated public services". EDF is the principal generator in France with an extensive portfolio of nuclear power stations.

Retail sales and grid access are separate businesses, although the DSO (Distribution System Operator) has commercial agreements to delegate residential and small commercial client relations to retailers (electricity suppliers provide one-stop "integrated contracts").

The major actors in the French electricity market are private actors with partial state ownership - EDF and its subsidiary companies (the French government owns 83,7% of EDF's share capital), ENGIE (the French government owns 23,64% of ENGIE's share capital).

The national energy regulator, Commission de regulation 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 DGEC. The CRE also judges conflict relating to grid access and must be consulted before the application of a range of grid access and management procedures, and before modifications are applied to the national Energy Code.

6.2 Interest from electricity utility businesses

France's major energy companies, EDF, ENGIE and TOTAL, are major international players, with a wide international portfolio covering both fossil (and nuclear) and renewable energies. There are no legal or regulatory barriers to their active involvement in photovoltaics generation in France, although EDF must demonstrate a complete separation of its public service delegations (network management, electricity contracts on government regulated prices) and commercial activities.

EDF Renouvelables (EDF Renewable for the international branch), a subsidiary of EDF, EDF Renouvelables Services (O&M services in Europe), and EDF Energie Nouvelles Réparties (EDF ENR), its own subsidiary, are both active in France. EDF ENR is active in the residential market. A second subsidiary company, 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 near 3 GW worldwide and owns roughly half this capacity, EDF also has near 1,5 GW under construction.

ENGIE has the biggest solar portfolio in France (more than 5% of the French photovoltaic installations in peak power) and has a comprehensive offer on all market segments, from residential to public and private development of utility scale ground-based systems.

Absent from the top 25 biggest photovoltaic producers in 2017, the oil & gas company TOTAL became in 2019 the 4th biggest producer of photovoltaic electricity in France. Although its strategy was primarily based on external growth (in particular through the takeover of Quadran in 2018), its growth is currently relying on successful results to competitive tenders.

EDF, ENGIE and TOTAL together control around 14% of the French photovoltaic production (rated in peak power).

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. Some municipalities tend to equip massively their building assets with photovoltaics by renting public roofs to private operators. In Saint-Etienne (around 400 000 inhabitants), a partnership between operator GreenYellow and the public authority foresees the installation of 20 MW on public assets.

Specific barriers continue to hamper local ambitions. The economical conditions are particularly stringent for local authorities mainly for two reasons:

- they tend to have infrastructure in close proximity, incompatible with feed-in-tariffs rules: feed-in Tariffs are limited to systems of 100 kW, and installations shall not be within a radius of 100 meters of each other, otherwise lowering the tariff

- direct access to competitive tenders faces two main hurdles: risk associated costs and binding calendar requirements generally incompatible with local authorities' direct investment.

However, as local authorities deploy mandatory and voluntary climate action plans, ambitious photovoltaics goals are becoming frequent. Furthermore, investment on infrastructure belonging to local authorities continues is accelerating, either through direct investment or by third party investment (commercial, private-public investment vehicles or citizen-led).

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. These targets may be ambitious, considering the current combined commissioned and project (grid connection queue) volume of approximately 17 GW. The PPE maintains and strengthens the priority given to the development of less costly ground based and parking canopy systems.

National photovoltaic capacity grew by 966 MW, more than the 862 MW in 2018 (884 MW in 2017), for a cumulative capacity of 9 904 MW for grid connected installations. Citizens have predominantly turned to partial self-consumption for residential systems, by T4 2019 approximately 2/3 of projects under 36 kW were for partial self-consumption. 2019 saw large volumes of commercial systems commissioned. The 9-250 kW segment grew by 30 %, while others have been stagnating.

2019 also saw under-subscriptions on competitive tenders for buildings. The tariffs of those tenders have respectively increased of 20 and 10% compared to 2018 ones. Meanwhile the cost of equipment has stagnated and even decreased.

7.2 Prospects

New competitive tender winning projects constitute more than 2 GW/year. The volume of projects being instructed has been increased from 1,5 GW in 2017 to near 7 GW today. Thus, 2020 should see around 1,5 GW commissioned. However, the current 2020 sanitary crisis could strongly impact this prediction.

If individual and collective self-consumption will continue to develop, it will continue to amount to a limited share of total installed peak power. The transposition into French law of European energy communities may however facilitate the prosumer market.

Up to now, roof-mounted systems were subject to feed-in-tariff under 100 kW. Energy minister announced the raise of this limit to 300 kW in February 2020. Moreover, decree n° 2020-382 related to regional schemes for grid connection of renewable energies published in March 2020 reduces grid connection fees for renewable energy producers below 250 kVA. Strong dynamic on commercials systems up to 300 kW is therefore expected in 2020.

Thus, the most significant market impact is likely to be the commissioning of roof-mounted systems on commercial sites and agricultural roofs and an increase in very large utility scale projects as major public and private landholders (the army, supermarkets operators) provide access to their infrastructure for investors.