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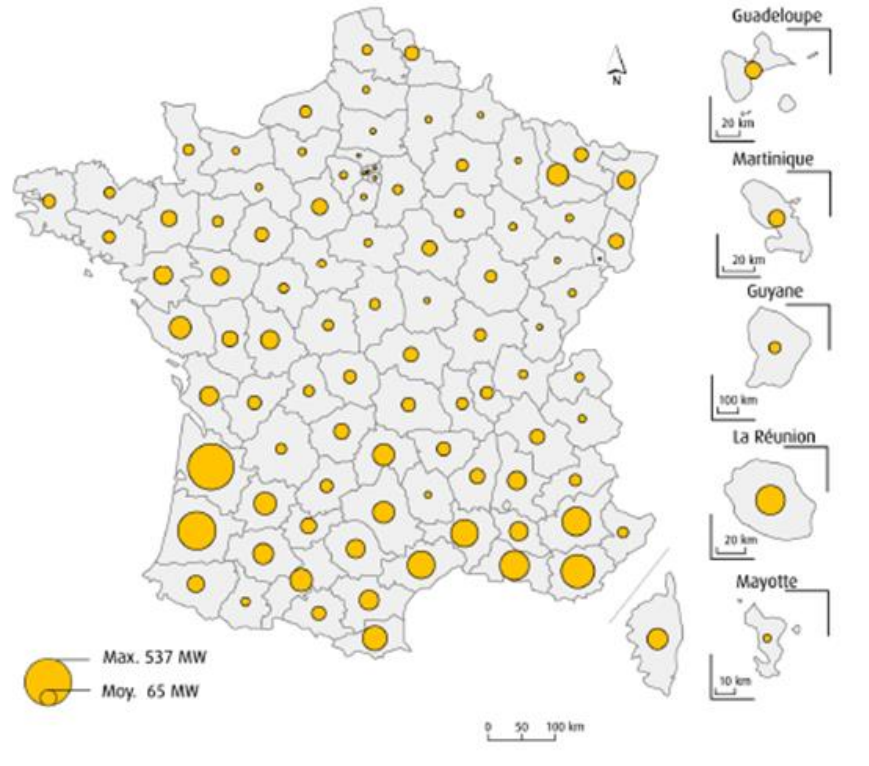
National Survey Report of Photovoltaic Power Applications in FRANCE 2015



PVPS

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

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French Environment and Energy Management Agency

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FRONT COVER: Distribution of PV installations in the French departments in 2015 (SOURCE: SOeS).

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FOREWORD

This report prepared by the French Environment and Energy Management Agency (ADEME), is part of a collaborative research project within the International Energy Agency photovoltaic programme (IEA-PVPS).

The French Environment and Energy Management Agency (ADEME) is a public organization under the authority of the Ministry of Environment, Energy and Sea* and the Ministry of National Education, Higher Education and Research.

ADEME participates actively in the implementation of public policies in the areas of the environment, energy and sustainable development. The agency provides expertise and advisory services to businesses, local authorities and communities, government bodies and the public at large, to enable them to establish and consolidate their environmental action. The agency also helps finance projects, from research to implementation, in the areas of waste management, soil conservation, energy efficiency, renewable energies, air quality and the fight against noise.

ADEME, designated by the French Government, has signed the IEA-PVPS cooperation agreement and thereby participates in the Executive committee of the IEA-PVPS programme; it also contributes to the work of Task 1 through its SRER department (Networks and renewables). www.ademe.fr

The International Energy Agency (IEA), founded in November 1974, is an autonomous body within the framework of the Organization for Economic Co-operation and Development (OECD) which carries out a comprehensive programme of energy co-operation among its member countries.

The IEA Photovoltaic Power Systems Technology Collaboration Programme (IEA-PVPS) is one of the collaborative R&D agreements established within the IEA and, since 1993 its participants have been conducting a variety of joint projects in the applications of photovoltaic conversion of solar energy into electricity.

The participating countries and organizations can be found on the www.iea-pvps.org website.

The overall programme is headed by an Executive Committee composed of one representative from each participating country or organization, while the management of individual Tasks (research projects/activity areas) is the responsibility of Operating Agents. Information about on-going and completed tasks can be found on the IEA-PVPS website www.iea-pvps.org. French experts participate in most of the current cost-shared studies of IEA-PVPS (Tasks 1, 9, 12, 13 and 15).

*In February 2016, the former Ministry of Ecology, Sustainable Development and Energy changed its name to Ministry of Environment, Energy and Sea and is mentioned as ‘Ministry of Environment’ in the report.

INTRODUCTION

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 report *Trends in Photovoltaic Applications*. In parallel, National Survey Reports are produced annually by each Task 1 participant. The PVPS website www.iea-pvps.org also plays an important role in disseminating information arising from the programme, including national information.

This document is the French National Survey Report on photovoltaics for the year 2015. It has been prepared by ADEME. The main sources of information used for the report are the following: data produced by the French Observation and statistics office (SOeS, *Service de l'observation et des statistiques*), ADEME's reports and studies, publications from Observ'ER/Systèmes Solaires and from the professional organizations SER and ENERPLAN, Plein Soleil magazine, institutional and professional websites, data from equipment suppliers, company publications and press releases, corporate strategy flyers and contacts with professionals in the sector**.**

REFERENCES

[1] - Tableau de bord éolien-photovoltaïque, SOeS, n° 732, February 2016, nº 765, May 2016 (Service de l'observation et des statistiques, Ministry of Environment).
[2] - Atlas 2015 des grandes centrales PV > 1 MW, Observ'ER, Journal du photovoltaïque n° 14, November 2015.
[3] - Panorama de l'électricité renouvelable en 2015, RTE, SER, ERDF and ADEeF, January 2016.
[4] - Bilan électrique 2015 (RTE Electricity Report 2015), RTE, February 2016.
[5] - Annuaire des adhérents, Syndicat des énergies renouvelables 2015, SER, November 2015.
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[8] - Photovoltaïque et collectivités territoriales – Guide pour une approche de proximité, ADEME, October 2014.
[9] - Marchés et emplois liés aux ENR. Study carried out by In Numeri for ADEME, private communication, March 2016.
[10] - Rapport sur l'autoconsommation et l'autoproduction de l'électricité renouvelable, December 2014, Ministry of Environment/DGEC.
[11] - Étude du cadre législatif et réglementaire applicable au financement participatif des énergies renouvelables, ADEME, 2015.

NOTE - The currency unit used throughout this report is the **euro** (EUR) and multiples: million euros (MEUR) and billion euros (GEUR).

1 INSTALLATION DATA

The photovoltaic (PV) power system market is defined as the market of all nationally installed (terrestrial) PV applications with a capacity of 1 kW or more. A photovoltaic system consists of PV modules, inverters, storage batteries and all installation and control components. Other applications such as portable devices are not considered in this report.

For the purposes of this report, PV installations are included in the statistics if the PV systems were installed and connected to the grid between 1 January and 31 December 2015, although commissioning may have taken place at a later date. Data of interest in this report are the power of systems, delivered energy and final yield. The nominal power of a photovoltaic system is calculated by adding up the unitary power of all its PV modules. In France, a photovoltaic system of one kilowatt produces around one thousand kilowatt-hours of energy over a year.

NOTE – The d.c. power of a PV module is measured in the manufacturing plant under standard test conditions (STC, 1 $kW \cdot m^{-2}$, 25 °C, AM 1,5). The photovoltaic power data published in this report are expressed in watts (W) and their multiples kW, MW and GW. Some professionals use the non-standardized unit peak-watt (W_p).

1.1 Applications for photovoltaics

Photovoltaic (PV) systems have been in operation in France since the 1980s. Initially, these systems were used to supply electrical energy to off-grid sites (remote homes, telecom relays, etc.). Since 2002, with the introduction of guaranteed feed-in tariffs, PV systems have been increasingly installed for supplying power to the public electricity grid.

1.2 Total photovoltaic power installed

1.2.1 Data collection process

The data given in this report refer to the PV power installed during the 2015 calendar year. The installed power is divided into two main applications, off-grid and grid-connected. The grid-connected capacity is either distributed or centralized. Estimated accuracy of installation data is ± 5 %.

The following definitions apply:

- Grid-connected distributed PV power system: electricity-producing system applied to residential, tertiary, commercial, industrial and agricultural buildings, or installed in the built environment (power range: kW to MW).

- Grid-connected centralized PV power system: ground-mounted production system that supplies bulk electrical power (power over 1 MW).

- Off-grid PV power system: system installed to provide power mainly to households or villages not connected to the electricity grid. Can also provide power to a variety of industrial and agricultural applications such as telecommunication relays, water pumping, safety and protection devices, etc. (power range: kW to several hundred kW).

NOTE – Also referred to as 'stand-alone PV power system': includes a storage battery and, in some cases, an additional source of energy (diesel generator, wind power…).

1.2.1.1 Grid-connected system applications

Data relating to grid-connected photovoltaic systems come from publications by the French statistics office SOeS [1]. SOeS statistics cover metropolitan France and the overseas departments/regions. They are supplied by the companies operating electricity distribution and transport: ERDF, RTE, EDF-SEI and local distribution companies (ELD). SOeS breaks down

installed power data into different power categories and into administrative departments/regions, both metropolitan and overseas.

The report *Overview of renewable electricity in 2015* [3] also provides statistics on grid-connected installations which are slightly different from those compiled by SOeS, since they do not include installations in overseas departments/regions and only rely on estimated end-of-year data. However, the Overview will be referred to for its detailed analysis of peak energy production, load factor and rate of consumption.

The PVPS National Survey Report guidelines request installed volume figures both for **centralized ground-mounted** and **distributed** applications. The *PV Atlas Observ'ER* [2] provides a list of ground-mounted photovoltaic installations with a power over 1 MW and a number of details such as the different types of applications, power capacity, location, commissioning dates, etc.

The installed volume of grid-connected **distributed applications** (residential, industrial, agricultural or commercial roofs, PV carports for car parks, greenhouse, etc.) has been assessed by calculating the difference between the global installed volume reported by the SOeS and the volume of centralized ground-mounted power plants published by the PV Atlas.

1.2.1.2 Off–grid system applications

Off-grid data refer to new photovoltaic installations but not to the replacement of PV modules or to a power increase in the systems already installed. The off-grid PV business can mainly be found in French overseas regions. Data for off-grid PV rural electrification come from the annual statistics of the FACE Fund.

1.2.2 Photovoltaic power installed in 2015

The grid-connected PV power installed in France in 2015 (metropolitan France and overseas department/regions) was estimated at 887 MW [1] compared to 951 MW in 2014, and 651 MW in 2013. Grid-connected distributed applications, which are mainly building-integrated systems, reached 294 MW (33 %) and centralized ground-mounted systems 593 MW (67 %) [1] [2]. Overseas departments/regions (DROM) accounted for 21 MW.

In 2015, the total power of photovoltaic off-grid applications was estimated at 400 kW, mainly from hybrid photovoltaic plants installed in the French overseas department of Guyane.

Table 1 displays annual installed power in the three categories of applications (grid-connected distributed, centralized ground-mounted and off-grid).

The global investment linked to PV installation in 2015 is estimated at 1,24 billion euros.

Table 1 – Photovoltaic power installed during the calendar year 2015 (MW)

Sub-market	Application	Power installed
Grid-connected	Distributed (Mainly building-integrated applications)	294 MW (33 %)
	Centralized ground-mounted	593 MW (67 %)
	Total grid-connected	**887 MW**
Off-grid	Off-grid rural electrification (mainly hybrid systems)	**0,4 MW**

SOURCE: SOeS (May 2016), PV Atlas Observ'ER, ADEME.

Table 2 details grid-connected installations in various power ranges for the year 2015. Compared to 2014 figures, there has been a 7 % decrease in power and a 35 % decrease in the number of installations, the downward trend being particularly marked for low power installations.

68 % of the annual installed volume is supplied by systems over 250 kW.

The Cestas PV plant near Bordeaux is the largest in Europe with a total power of 300 MW (of which 230 MW were grid-connected by the end of 2015). It is mounted on fixed structures with an east-west orientation and benefits from a T5 guaranteed feed-in tariff (2012).

Systems up to 9 kW represent 10 % of power and 86 % of the total number of installations.

The average power of all installations increased from 19 kW in 2013 to 35 kW in 2014 and 51 kW in 2015.

Table 2 – Grid-connected installed capacity during the calendar year 2015 (MW)

Power range	Application	Installation number (% of total)	Power (MW) (% of total)
0 – 3 kW	Full building integration (IAB)	32,1 %	1,8 %
3 kW – 9 kW	Full building integration (IAB)	54,3 %	8,2 %
9 kW – 36 kW	Simplified building integration (ISB)	2,9 %	1,6 %
36 kW – 100 kW	Simplified building integration (ISB)	8,7 %	14,7%
100 kW – 250 kW	Simplified building integration (ISB)	1,5 %	5,8 %
> 250 kW	Large rooftops, ground-mounted plants…	0,6 %	67,9 %
Total		**17 845** (100 %)	**887 MW** (100 %)

SOURCE: SOeS (May 2016). Definitions of IAB and ISB are given in 3.1.5.

The figures above have contributed to the overall statistics of the 'Snapshot of Global PV Markets 2015' published by the IEA-PVPS. At the end of 2015, the worldwide market reached 277 GW with 50 GW installed during the year, up from 40 GW in 2014.

Figure 1 and Figure 2 show the evolution of installed power between 2011 and 2015 according to various power ranges (Source: SOeS, ADEME).

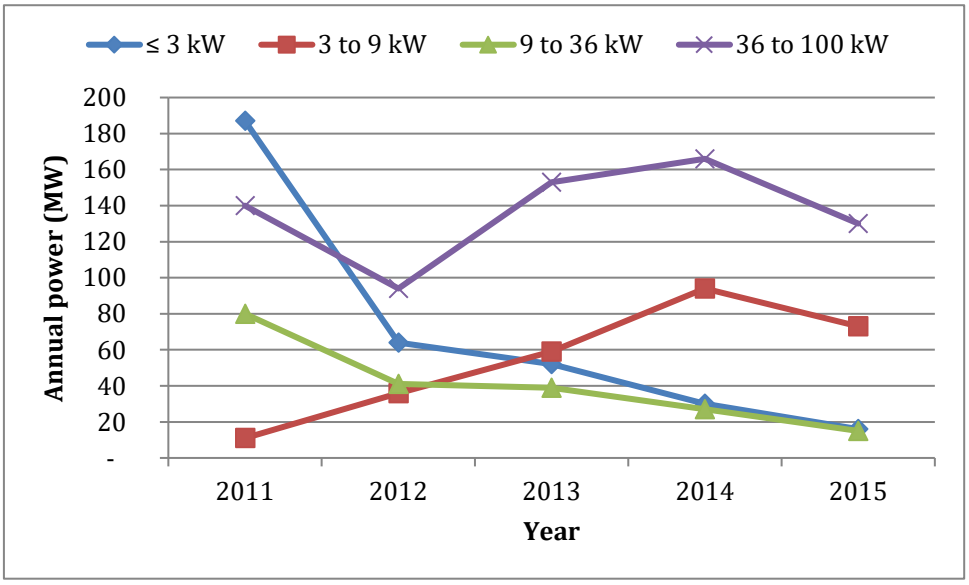

Figure 1 – Installed volume by power ranges up to 100 kW, 2011-2015

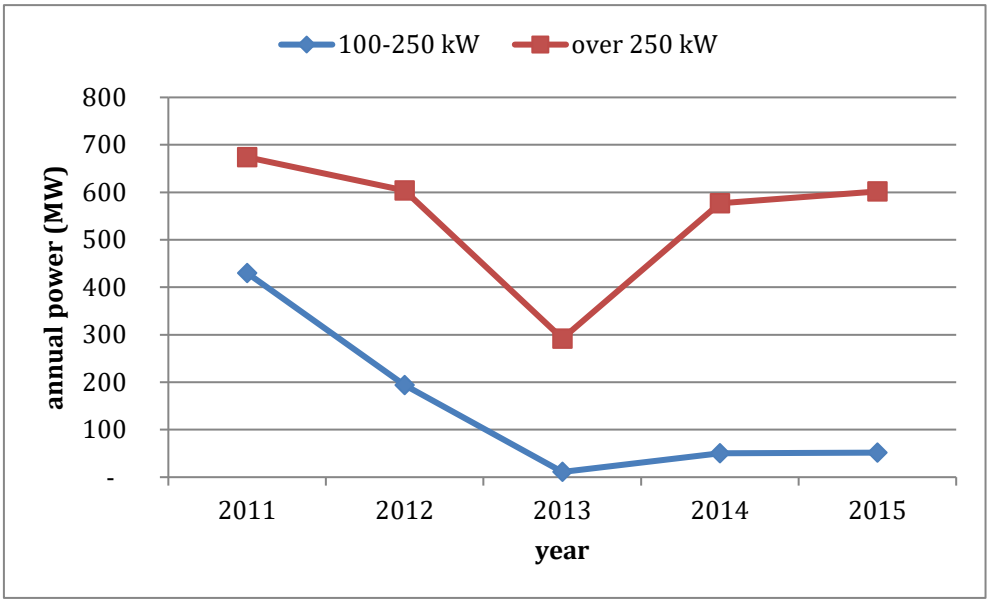

Figure 2 – Installed volume by power ranges over 100 kW, 2011-2015

1.2.3 Photovoltaic production and the energy market

Table 3 shows PV electricity production in 2015 in relation to the electrical energy market in metropolitan France (excluding the overseas departments). All data come from the French Electricity Report published by the French electricity transmission system operator RTE [4]. PV electrical energy production is estimated at 7,4 TWh, a 25 % increase on the previous year. Photovoltaic capacity represents 4,8 % of the total national power generation capacity. PV electrical energy production covers 1,6 % of national electrical energy consumption. In 2015, 43 % of new global electricity generation capacities installed in metropolitan France came from photovoltaic systems installed during the year.

The *Overview of Renewable Electricity in 2015* [3] points out that a peak of PV power generation was reached at 14:00 on 24 June 2015 with 4 601 MW, and that consumption coverage rose to a high of 11,2 % at 15:00 on 2 August 2015. The annual average load factor was 15 %, peaking at 83,5 % on 21 April 2015. The publication also provides a detailed analysis of PV production, load factor, rate of consumption in each of the metropolitan French regions.

Table 3 – PV power and the broader national energy market

	2015	2014
Total power generation capacities (all technologies)	Total: 129 310 MW of which Nuclear: 63 130 MW; Fossil fuel: 22 553 MW; RES: 43 627 MW (see below)	Total: 128 943 MW of which Nuclear: 63 130 MW; Fossil fuel: 24 411 MW. RES: 41 402 MW (see below)
Total power generation capacities (renewables including hydropower)	**PV***: 6 191 MW **(4,8 %)**; Hydro: 25 421 MW; Wind: 10 312 MW; Other RES: 1 703 MW.	**PV***: 5 292 MW **(4,1 %)**; Hydro: 25 411 MW; Wind: 9 120 MW; Other RES: 1 579 MW.
Total electricity consumption	476 TWh	465 TWh

New power generation capacities installed during the year (all technologies)	Total: 2085 MW of which Gas: +63 MW; Coal: -1 500 MW; Fossil fuel: + 23 MW; Nuclear: 0 MW; PV and other RES: 1 999 (see below).	Total: 1 990 MW of which Gas: + 9 MW; Coal: - 1 240 MW; Fossil fuel: - 65 MW; Nuclear: 0 MW; PV and other RES: 1 982 (see below).
New power generation capacities installed during the year (renewables including hydropower)	**PV***: + 895 MW **(43 %);** Wind: + 999 MW (48 %); Hydro: - 1 MW; Other RES: + 105 MW.	**PV***: + 927 MW **(46 %);** Wind: + 963 MW (48 %); Hydro: - 23 MW; Other RES: + 92 MW.
Total PV electricity production	**PV: 7,4 TWh**	**PV: 5,9 TWh**
Total PV electricity production as a % of total electricity consumption	**1,6 %**	**1,3 %**

SOURCE: RTE France Electricity Reports for 2014 and 2015.*RTE provisional PV figures differ from those of SOeS.

Table 4a – Number of PV installations at the end of 2015

	Number of installations
Total France (grid-connected)	**365 810 installations**
- metropolitan France	**98,2 % (average power: 17 kW)**
- overseas departments/regions	**1,8 % (average power: 56 kW)**

SOURCE: SOeS (May 2016), ERDF, RTE, EDF-SEI, CRE, ELD.

Table 4b – State of grid connection at the end of 2015

	PV power
Total France (grid-connected) - metropolitan France - overseas departments/regions	**6 559 MW** **94,5 %** **5,5 %**
PV capacity connected to the low and medium voltage distribution grid (metropolitan France)	**91 %**
PV capacity connected to the high voltage HVB transmission grid (metropolitan France).	**9 %**
NOTE - Low voltage LV: < 250 kVA; High voltage HVA: 250 kVA - 12 MVA; High voltage HVB: > 12 MVA, 63 kV to 400 kV.	

SOURCES: SOeS (May 2016), ERDF, RTE, EDF-SEI, CRE, ELD.

CRE calls for tenders require that PV plants provide their daily energy production data. RTE has developed IPES, a software planning tool, to keep constant track of wind and solar energy production and to make 48-hour production forecasts. The French electricity mix, which includes PV, is published in real time on the RTE website Eco2mix.

1.2.4 Cumulative installed capacity

Table 5 shows the cumulative installed PV power broken down into three sub-markets: grid-connected distributed, grid-connected centralized and off-grid.

Table 5 – Cumulative installed PV power at the end of 2015 (MW)

Sub-market	Application	Power (MW)
Grid-connected	Distributed (Mainly building-integrated installations)	4 257 MW (65 %)
	Centralized ground-mounted plants	2 302 MW (35 %)
	Sub-total grid-connected	**6 559 MW** (100 %)
Off-grid	Rural electrification	**30,15 MW**

SOURCE: SOeS, PV Atlas Observ'ER and ADEME.

Table 6 – Grid-connected cumulative installed PV power at the end of 2015

Power range	Application	Installation number (% of total)	Power (MW) (% of total)
0 – 3 kW	Full building integration (IAB)	76,4 %	11,4 %
3 kW – 9 kW	Full building integration (IAB)	14,3 %	5,0 %
9 kW – 36 kW	Simplified building integration (ISB)	4,5 %	6,2 %
36 kW – 100 kW	Simplified building integration (ISB)	2,9 %	12,7 %
100 kW – 250 kW	Simplified building integration (ISB)	1,5 %	14,8 %
> 250 kW	Rooftop and ground-mounted plants	0,3 %	49,9 %
Total		**365 810 inst.** (100 %)	**6 559 MW** (100 %)

SOURCE: SOeS (Feb., May 2016).

Table 7a – Cumulative installed PV power in 3 sub-markets, 2006-2015 (MW)

Application	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Off-grid	21,5	22,5	22,9	29,2	29,3	29,4	29,6	29,7	29,75	**30,15**
Grid-connected **centralized** ground-mounted	0,0	0,0	7	42	242	702	1 012	1 264	1 709	2 302
Grid-connected **distributed**	16	53	150	300	938	2 242	3 052	3 454	3 963	4 257
Grid-connected total	16	53	157	342	1 180	2 944	4 064	4 718	5 672	**6 559**

SOURCE: SOeS and previous IEA NSR reports for France. NOTE: A few figures from previous IEA NSR reports have been reviewed to take into account the latest adjustments from SOeS, PV Atlas Observ'ER and ADEME.

Table 7b – Cumulative installed PV power, 1992-2005 (MW)

1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1,8	2,1	2,4	2,9	4,4	6,1	7,6	9,1	11,3	13,9	17,2	21,1	24,2	25,9

SOURCE: ADEME.

Figure 3 shows the evolution of national grid-connected photovoltaic power between 2007 and 2015 (annual installation volume and cumulative capacity at the end of each year, MW).

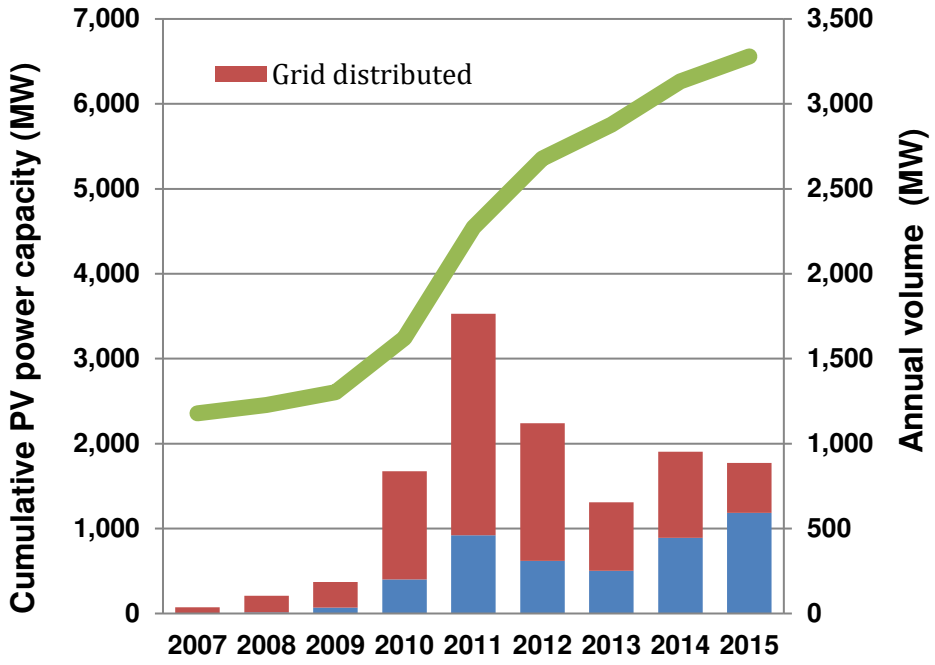

Figure 3 – Annual and cumulative capacity of grid-connected PV installations in France

The main PV implantation areas are situated in the sunniest southern regions of metropolitan France. Table 8 shows the four most active regions: they represent 67 % of cumulative capacity and 53 % of the number of installations. In 2015, the power installed in these regions represented 85 % of the annual power installed in France.

Table 8 – PV installations in four French Regions

Regions with a power capacity > 500 MW	**Cumulative installed capacity at the end of 2015** (% of total capacity)	**Installation number** (% of total number)	**Grid-connected power during 2015** (% of annual power)
Aquitaine – Limousin – Poitou-Charentes	24 %	13,8 %	50,4 %
Languedoc-Roussillon – Midi-Pyrénées	19 %	14,7 %	17,2 %
Provence – Alpes – Côte d'Azur	13 %	9,0 %	11,6 %
Auvergne – Rhône-Alpes	10 %	15,9 %	5,9 %
Total for 4 regions	**4 387** MW (67 %)	**194 642** installations (53 %)	**748** MW (85 %)
Total France (including DROM)	**6 559 MW** (100 %)	**365 810** installations (100 %)	**887 MW** (100 %)
NOTE - In 2015, the 22 administrative regions of metropolitan France were merged into 13 regions. Their classification is different from the previous years since some regions have been given temporary names by combining the former regions' names. The five overseas regions were not affected by the mergers.			

SOURCE: SOeS (Feb., May 2016).

France is divided into 18 administrative regions including 13 metropolitan regions and 5 overseas regions. Each of all the French regions is further subdivided into departments.

In France, 90 % of installed PV modules are made of crystalline silicon cells and 10 % are thin film modules (essentially cadmium telluride material used for ground-mounted power plants).

French overseas departments/regions (DROM) represent 5,5 % (363 MW) of total national PV capacity and 1,8 % of the number of installations. The region of La Réunion alone, accounts for 50 % of installed power capacity in the DROM.

2 COMPETITIVENESS OF PV ELECTRICITY

2.1 Module prices

Most French PV crystalline silicon module manufacturers use their products either for their own installation projects or for their regular partners. Prices of standard crystalline silicon modules range from 0,57 EUR/W to 0,62 EUR/W (exclusive of VAT). Some manufacturers mention a price drop of 5 % in 2015.

2.2 System prices

Systems installed in France refer to different categories of applications. The PV array is installed on existing or new buildings (residential, commercial and agricultural) with two configurations: building-integrated (BIPV-IAB or BIPV-ISB) or building-attached (BAPV). Alternatively, the PV array can be ground-mounted on fixed structures or on solar trackers.

Table 9a shows the turnkey price ranges for the following applications: existing residential building with full integration (BIPV-IAB), large PV rooftops with simplified integration (BIPV-ISB) and ground-mounted PV plant (fixed structure without energy storage).

Table 9a – Turnkey prices of typical grid-connected applications (EUR/W)

Category/Size	Typical applications	Price range
BIPV-IAB* rooftop up to 9 kW	Residential full building integration Existing building	2,4-3,0 EUR/W
BIPV-ISB** rooftop 36 kW to 100 kW	Educational building Simplified building integration	1,7-2,3 EUR/W
Simplified integration ISB, Large rooftop 100 kW to 250 kW	Industrial/commercial building, Large rooftop ISB	1,5-1,7 EUR/W
Centralized ground-mounted, 5-10 MW	Centralized production, utility-scale plant Fixed structure (no storage)	0,9-1,3 EUR/W

SOURCE: ADEME [6] [9]. VAT not included. *BIPV-IAB: full building integration; **BIPV-ISB: simplified building integration.

Table 9b shows the general trends in average turnkey prices of typical applications.

Table 9b – National trends in average system prices (EUR/W)

Application	2007	2008	2009	2010	2011	2012	2013*	2014*	2015*
Residential BIPV-IAB rooftop up to 9 kW, existing building	8,4	8,2	6,9	5,9	3,9	3,7	2,7	2,6	2,5
Large commercial BIPV-ISB rooftop 36 kW to 100 kW,	7,8	7,6	6,4	5,5	2,6	2,0	2,0	2,0	1,9
Centralized ground-mounted 5-10 MW	6,3	6,2	5,2	4,5	2,0	1,6	1,3	1,3	1,2
*NOTE – The Table includes BIPV-IAB systems up to 3 kW until 2012, and BIPV-IAB systems up to 9 kW since 2013.									

SOURCE: ADEME, ref [9]. VAT not included. *IAB: full building integration; **ISB: simplified building integration.

Table 10a compares the costs of full building integration (BIPV-IAB) and simplified building integration (BIPV-ISB) for new and existing buildings in two application categories: residential and large commercial rooftops. The reference cost is the less costly option of a BAPV rooftop with crystalline silicon standard modules.

Table 10a – Cost comparison BIPV (full and simplified) versus BAPV

Application category	Building type	Power segment	BIPV (IAB or ISB) vs BAPV
BIPV-IAB* PV rooftop Full integration	New	Up to 3 kW	IAB: + 7,0 %
		3 kW to 9 kW	IAB: + 3,5 %
	Existing	Up to 3 kW	IAB: + 27 %
		3 kW to 9 kW	IAB: + 31 %
BIPV-ISB** Large PV rooftop Simplified integration	New	36 kW to 100 kW	ISB: + 4,0 %
	Existing	36 kW to 100 kW	ISB: + 22 %
	Existing	100 kW to 250 kW	ISB: + 9,1 %

SOURCE: ADEME [6]. *BIPV-IAB: full building integration; **BIPV-ISB: simplified building integration; BAPV: building-attached PV.

2.3 Cost breakdown of PV installations

Table 10b shows the cost breakdown for typical PV systems (source ADEME [6]).

Table 10b – Cost breakdown for three types of PV systems (%)

Cost category	Rooftop IAB* up to 9 kW	Rooftop ISB** 36 kW to 100 kW	Ground-mounted > 1 MW
Hardware			
PV modules	24 %	26 %	42 %
Inverter, electric equipment	16 %	21 %	8 %
Support structure	12 %	11 %	8 %
Soft costs (installation, acquisition, profit, other)			
Installation	36 %	31 %	25 %
Other costs	12 %	11 %	17 %
Subtotal hardware	52 %	58 %	58 %
Subtotal soft costs	48 %	42 %	42 %
Total	100 %	100 %	100 %

SOURCE: ADEME [6]. *BIPV-IAB: full building integration; **BIPV-ISB: simplified building integration.

2.4 Financial parameters and financing programmes

The wide scope of grid-connected applications from residential PV rooftops to large PV commercial/industrial rooftops and ground-mounted utility-scale plants requires specific financing tools.

Large PV projects, based on 20-year electricity purchase contracts, attract project debt financing starting at 5 MEUR and covering up to 80 % of the total capital. Financial companies provide loans with up to an 18-year amortization period.

The financing framework for utility-scale PV projects can be implemented jointly with the European Investment Bank (EIB) and several different commercial banks. The EIB, the long-term lending bank of the European Union, can contribute up to 50 % of the planned investment.

For local projects (for example, commercial centres or social housing), mechanisms based on leasing are attractive to building owners. Energy cooperatives are helping citizens to take part in local projects.

Crowdfunding is an interesting financial instrument for citizen involvement in the Energy transition. A crowdfunding platform can contribute up to 20 % of project financing through debt, bond or quasi-equity. The other 80 % can come from equity providers and banks.

French Regions are actively involved in Energy transition. In this context, ADEME has issued two relevant publications *Photovoltaics and Territorial Collectivities* [8] and a 'Study of the legislative and regulatory framework for participatory financing of renewable energy' [11].

As early as March 2011, the Poitou-Charentes authorities chose to support the photovoltaic sector with the ESTER scheme (Regional Solar Electricity). This public-private partnership for the production of PV electricity at a controlled cost is the result of a unique alliance between the region, an independent PV operator and local energy distribution companies.

Case study

In a recent publication, the French editor Observ'ER examines some financing schemes applying to different types of PV installations such as residential, social housing, large shopping centres and industrial parks. The study looks into two PV projects: 'Soleil du Grand Ouest shopping centre' and 'Savoie-Technolac Technology Park'. This study is part of a project funded by the EU Horizon 2020 research and innovation programme, PV FINANCING (pv-financing.eu). It is a valuable source of information on the financial parameters and financing programmes of the seven participating countries. The project aims at identifying the most profitable business models and financing schemes for PV systems.

Training sessions

FINER, is a series of training sessions on project finance. The sessions, managed by the consultancy firm Metrol, analyze the characteristics, the advantages and disadvantages of different financing schemes: equity contribution, senior debt, direct sales of energy on the market, additional compensation, mezzanine finance, etc. The training is open to all actors involved in financing renewables.

2.5 Country information

Table 11 provides additional information regarding France's population and parameters related to its electricity system. More information on its electricity market is given in Section 7.1.

Table 11 – Country information

Retail electricity prices: household, commercial company	Household: 0,1503 EUR$_{TTC}$/kWh; Commercial: 0,0891 EUR$_{HT}$/kWh.
Country parameters, population, size	France = Metropolitan France (continental France + Corsica Island), 13 Regions + 5 overseas departments/regions (Guadeloupe, Guyane, Martinique, Mayotte, Réunion). Population 64 million in metropolitan France and 1,9 million in overseas departments. Area of metropolitan France: 552 000 km²; Area of overseas (DROM): 81 100 km².
Average annual PV yield (kWh/kW)	Average of continental France: 1 100 kWh/kW; North of continental France: 900 kWh/kW; South of continental France: 1 300 kWh/kW; Overseas departments: 1 450 kWh/kW.
Name and market share of major utilities.	EDF SA (Électricité de France): 100 GW; 466 TWh ENGIE: 10 GW.
Transmission	RTE *(Réseau de transport d'électricité).*
Distribution	ERDF/ENEDIS, EDF-SEI (for Corsica and DROM and not Mayotte), Électricité de Mayotte, as well as main local distribution companies (ELD): Électricité de Strasbourg, Coopérative d'électricité de Saint-Martin-de-Londres, Gérédis and Sorégie, etc.

3 POLICY FRAMEWORK

The development of photovoltaic applications in France has been driven by national and regional support policies.

In the early 1980s, support measures were geared towards rural electrification of off-grid sites. The deployment of grid-connected power installations started in 2002, with the obligation for EDF and other local distribution companies to purchase renewable electricity at a fixed rate (feed-in tariff).

3.1 Direct support measures

Since an Order was issued in March 2011, the main support mechanism for promoting grid-connected photovoltaic applications has included two complementary incentives based on the power of installations:

- PV installations up to 100 kW: purchase obligation scheme (feed-in tariffs with a quarterly adjustment);
- PV installations from 100 kW to 12 MW: tender procedures (purchase tariffs resulting from bidding).

Table 12 summarizes the on-going national and regional support measures.

Table 12 – Summary of national and regional PV support measures, 2015

Ongoing support measures	Authorities in charge
Purchase obligation (feed-in tariffs) mainly for grid-connected building-integrated applications	National
Purchase tariff through calls for tenders for systems over 100 kW (rooftop, ground-mounted installations…)	National
Income tax credit for residential BIPV roof owners	National (Measure phased out 1 January 2014)
FACE fund for rural electrification (off-grid applications)	National
Capital subsidies for equipment or total cost	Local authorities through calls for proposals
Prosumers' incentives (self-consumption)	Local authorities through calls for proposals

At the beginning of 2016, the government decided to revise the 2009 Multi-year programme for investment in the power sector: the volume of 5 400 MW for PV applications initially set for 2020, was increased to 10 200 MW for 2018, and to 18-20 GW for 2023.

The Energy Transition for Green Growth Act, promulgated in August 2015, will implement some new practices from 1 January 2017 (see 3.1.10).

3.1.1 Feed-in tariffs

Key dates of the policy of PV feed-in tariffs are presented in Table 13.

Table 13 – Key dates of the feed-in tariff support policy

13 March 2002	Purchase obligation scheme. PV feed-in tariff (FIT) of 0,1525 EUR/kWh (0,3050 EUR/kWh in Corsica and DROM).
10 July 2006	Order introducing a feed-in tariff (FIT) of 0,55 EUR/kWh (including a 0,25 EUR/kWh premium for building integration).
10 Dec. 2010	Three-month suspension of the purchase obligation scheme for installations exceeding 3 kW (the measure did not affect residential installations of 3 kW).
4 March 2011	Order indicating the new applicable feed-in tariffs. Introduction of a quarterly FIT adjustment for installations on buildings up to 100 kW and of a call for tenders procedure for PV installations over 100 kW.
7 January 2013	Simplification of the FIT pricing structure and introduction of a bonus of 5 % or 10 % for projects using PV modules manufactured in the European Economic Area (measure applied to 10 March 2014). From 2013 onwards, the T1 tariff for BIPV-IAB applications has been applied to systems up to 9 kW.
March 2014	Feed-in tariff bonus of 5 % or 10 % (see above) withdrawn 10 March 2014.
April 2015	T4 tariff increased by 10 % (Table 14).
	NOTE: CFE tax. The owners of residential BIPV systems with a power up to 9 kW are exempted from the CFE tax due to local authorities by businesses.

The purchase tariffs are set either by ministerial Order (Table 14) or by calls for tenders (see 3.1.2). In both cases, tariffs are guaranteed over a period of 20 years.

Once fixed by contract, feed-in tariffs are adjusted on an annual basis using a specific coefficient fixed by the National Organization of Statistics (INSEE).

PV electricity is purchased by EDF OA (EDF Agence obligation d'achat) as well as by local distribution companies (ELD).

The feed-in tariff policy is financed by the Contribution to Electricity Public Services (CSPE), a fee paid by electricity consumers (see 3.1.11).

Table 14 – PV feed-in tariffs for the 4th quarter of 2015 (EUR/kWh)

Power of PV installation (W)	Tariff category and PV system type	Tariff Q4 2015 (EUR/kWh)	2015 Annual variation (%)	Variation since March 2011 (%)
P ≤ 9 kW	**FIT T1 –** Full building integration (IAB)	0,2539	- 5,9 %	- 44,8 %
P ≤ 36 kW	**FIT T4 -** Simplified building integration (ISB)	0,1440	+ 4,8 %	- 52,6 %
36 kW < P ≤ 100 kW		0,1368	+ 4,8 %	- 52,5 %
P < 12 MW	**FIT T5 -** Other installations	0,0612	-10 %	- 49,0 %
100 kW < P ≤ 12 MW	**Calls for tenders** Rooftops, ground-mounted, carports…	0,0820 Example of electricity selling price proposed by bidders for ground-mounted plants		- 45 % (ground-mounted)
NOTE 1: In 2013, T2 and T3 tariffs were included into T1 and T4 categories. Technical and non-technical requirements for full building integration (IAB) and simplified building integration (ISB) are detailed in the Order of 4 March 2011 (see 3.1.5). NOTE 2: Increase of T4 tariff in 2015.				

SOURCE: CRE, Ministry of Environment, Energy and Sea.

3.1.2 National calls for tenders

National calls for tenders for photovoltaic grid-connected installations with a power over 100 kW were launched as early as 2011. Table 15 gives details of all the calls up to the beginning of 2016. The French Regulatory Commission of Energy (CRE), in charge of regulating the electricity and gas markets, manages all the PV national calls for tenders on

behalf of the Ministry of Environment. One of the selection criteria is the price that the bidder wishes to charge for the electricity supplied to the grid over a period of 20 years.

In 2015, the development of new PV capacity through calls for tenders was confirmed by the Energy Transition for Green Growth Act (Table 16).

3.1.2.1 Calls for tenders for 100 kW-250 kW systems

Calls for tenders, so-called 'simplified', refer to the construction and operation of photovoltaic installations on buildings between 100 kW and 250 kW. These installations have to comply with the rules governing simplified building integration (BIPV-ISB). The first series of calls was launched in July 2011.

Projects were selected according to two criteria: the submitted electricity price (weighting coefficient 2/3) and the carbon footprint assessment of the PV module manufacturing process (weight 1/3). The results of the 2011 call were published in 2013, leading to the selection of 756 projects totalling 156,9 MW, well below the target volume of 240 MW (Table 15).

In November 2014, the Ministry of Environment announced the results of the second series of calls launched in March 2013, the volume slightly exceeding the initial target with a total power of 121,7 MW and 587 projects.

A third 'simplified' call for tenders for a volume of 120 MW with three bidding phases of 40 MW each was issued in March 2015. In July 2015, the ministry doubled the capacity up to 240 MW (3 phases of 80 MW), targeting the additional volume for agricultural buildings. In March 2016 the ministry published the results of the first phase with a list of 349 projects totalling 80,2 MW (PV rooftops and PV carports for car parks). The projects were granted an average tariff of 139 EUR/MWh - a 9 % reduction compared to the call of March 2013.

Bids for the second and third phases ended on 21 March 2016 and 21 July 2016, respectively.

3.1.2.2 Calls for tenders for systems over 250 kW

Calls for tenders, so-called 'ordinary', refer to the construction and operation of photovoltaic installations over 250 kW and up to 12 MW. The specifications for these types of projects require a stricter environmental and industrial quality, including mandatory end-of-life dismantling and recycling. The first call for tenders 'CRE 1 > 250 kW' was launched in September 2011 (target 450 MW). The PV systems involved were PV on buildings (ISB), ground-mounted power plants (some with a storage facility), PV carports for car parks, concentrator photovoltaics (CPV) and solar thermal electrical plants. 105 projects for a total of 520 MW were selected, exceeding the initial objective by 70 MW.

A second ordinary call 'CRE 2 > 250 kW' was launched in March 2013 with a target volume of 400 MW. It concerned PV on buildings, ground-mounted PV power plants with solar trackers, concentrator power plants, mixed installations concentrator/non-concentrator and PV carports. The tender specifications included the development of ground-mounted plants on wasteland (brownfields, old quarries or rubbish dumps…). They also required that the environmental impact, industrial risks and the carbon footprint of frameless PV modules should be assessed. The official results of the call for tenders were published in early 2014 and 121 projects were accepted for a total of 380 MW. The applicants' lowest electricity price was for power plants with solar trackers and the highest for concentrator CPV plants.

The third ordinary call for tenders CRE 3 was launched in November 2014 with the initial target of 400 MW, which was raised to 800 MW over the year 2015. Ultimately, the call led to the selection of 1 100 MW, the bid submission deadline being set on 1 June 2015.

The call specified that installations on agricultural land would not be eligible and that a bonus would be given to innovative projects and wasteland use. Among other requirements, the call

specified that bidders should provide the electricity grid manager with PV plant operating information. The call's applications were for large rooftops (simplified building integration and building attached BAPV applications ≤ 5 MW), ground-mounted plants and PV carports for large car parks.
In December 2015, the Ministry published the list of winners: 253 projects for a total power of over 1 100 MW. There was a 15 % to 23 % fall in the average electricity prices compared to the previous CRE 2 selection (Table 15). Half of the PV modules used on the new plants will be manufactured in France.

3.1.2.3 Calls for tenders for PV plants with storage

The third type of national calls relates to non-interconnected insular territories (ZNI). ZNI territories are the French island of Corsica and the French overseas regions that are not connected to the continental electricity grid. Following the Decree of 23 April 2008, a maximum of 30 % penetration rate for renewables was allowed so as to limit the influence of load imbalance on the grid. The storage batteries associated with PV plants contribute to the stability of the local power grid, since surplus electrical energy is stored and released when needed.

The 2011 CRE 1 call for tenders had already reserved a volume of 50 MW for power plants with storage in ZNI territories. In 2014/2015, several plants were installed in these territories with power ranging from 5 MW to 10 MW and storage capacity from 5 MWh to 10 MWh. As a result, the Reunion Island's electricity grid is now able to withstand a 32 % penetration of renewables at any given moment. The multi-year energy programme (PPE Reunion) targets 50 % by 2020 and 100 % by 2030.

In May 2015, the Ministry of Environment issued a call for tenders to install new PV plants (> 100 kW) with storage in ZNI territories. The target volume of 50 MW was equally divided between installations on buildings (projects < 1,5 MW) and ground-mounted installations (< 5 MW) including PV carports for large car parks. The electricity price was set between 140 EUR/MWh and 400 EUR/MWh. The submission deadline was fixed on 20 November 2015. The CRE shortlisted 217 bids, representing 356 MW and seven times the initial target. The Ministry was to publish the final selection by mid-2016.

3.1.2.4 Summary table of calls for tenders

Table 15 gives detailed information on the national calls for tenders up to March 2016. The calls led to the selection of 2 111 PV installations with a total power of 2 347 MW. The weighted average bid price of eligible projects ranged from 82 EUR per MWh to 213 EUR per MWh according to the types of applications.

Table 15 – Calls for tenders for PV systems over 100 kW (up to March 2016)

Call type		Target volume (MW)	Achieved volume (MW)	Number of installations	Average electricity selling price (EUR/MWh)
1 – 'Simplified' calls 100 kW to 250 kW Simplified building integration	**First (2011-07) and second series of calls (2013-03)**	360 MW	**267**	**1 283**	212* (1st series) 162* (2nd series)
	Third series of calls 3 phases (launched 2015-03) 1st phase results published in 2016-03	3 phases of 80 MW	**80** (1st phase)	**349**	139
2 – 'Ordinary' calls 250 kW to 12 MW Large rooftops, PV carports, Ground-mounted plants, …	**CRE 1 (2011-09) CRE 2 (2013-03)**	850 MW	**900**	**226**	213* (CRE 1) 142* (CRE 2)
	CRE 3 (2014-11) Results published in 2015-12	1 100 MW	**1 100** (Applications: 2 200 MW)	**253**	Large rooftop: 129 (-18 %**) PV carport: 124 (-15 %**) Ground-mounted: 82 (-23 %**)
3 – 'ZNI call'[1)] for PV plants > 100 kW with storage	**ZNI 1 (2015-05)** *Results to be published in 2016*	50 MW	*n/a*	*n/a*	*n/a*

Total		2 600 MW	**2 347 MW** (not incl. phases 2 & 3 of 3rd series and ZNI call)	**2 111** installations (not incl. phases 2 & 3 of 3rd series and ZNI call)	

* Weighted average calculated on eligible projects corresponding to different types of systems. Provisional value.
** Compared to preceding call.
1) ZNI: non-interconnected territories (Corsica and French overseas islands).
SOURCE: CRE and Ministry of Environment, Energy and Sea.

3.1.2.5 Provisional calendar of national calls

In November 2015, the Ministry of Environment issued the 2016-2019 provisional calendar of calls for tenders for systems over 100 kW, with a total volume of 4 350 MW (Table 16). Two types of applications are taken into account: building installations (1 350 MW) and ground-mounted plants (3 000 MW). The new support mechanism implemented by the law on Energy Transition will apply: electrical energy will be sold directly on the electricity market with a premium.

The provisional calendar is part of the new Multi-year energy programme (PPE).

Table 16 – Provisional calendar of calls for tenders 2016-2019 (MW)

Application	2016	2017	2018	2019	Total
Rooftop	2 calls × 150	3 × 150	3 × 150	1 × 150	1 350
Ground-mounted	1 call × 500	2 × 500	2 × 500	1 × 500	3 000
Total	800	1 450	1 450	650	4 350

SOURCE: Ministry of Environment, Energy and Sea.

3.1.3 Calls by regional and local authorities

France's regional and departmental authorities and a number of municipalities have set up several promotion policies to boost the PV sector. The regions of Alsace, Aquitaine, Guadeloupe, Languedoc-Roussillon, Pays de la Loire and Poitou-Charentes have issued calls for proposals for photovoltaic self-consumption projects. The calls show a particular interest in the energy efficiency of buildings with no specific requirements regarding building integration.

The beneficiaries can be local authorities and public or private sectors. The financial support granted, can be either an investment aid or a capped repayable advance. Preliminary studies can also receive financial support from ADEME.

In June 2015, a joint call on self-consumption without the option of selling surplus power was launched by the regional council of Guadeloupe and ADEME.

At local level, a number of municipalities are implementing their Territorial energy, air and climate plan (PCAET). To help collectivities in their PV development strategies, ADEME has published *Photovoltaics and Territorial Collectivities* [8], a guide with case-studies on the economic, societal and environmental benefits of PV systems.

3.1.4 Self-consumption measures

Photovoltaic projects under FIT contracts allow partial consumption of electricity production. So far there has been no premium for self-consumption. As seen above (3.1.3), some Regions are promoting self-consumption projects through their calls for proposals. The calls, mainly targeted at tertiary buildings, must comply with the required rate of self-consumption and injected power.

In early 2015, the Directorate for Energy and Climate (DGEC) of the Ministry of Environment published a report on self-consumption/self-production issues [10]. After stakeholder

consultation, a national call for self-consumption/production projects was due to be launched in 2016.

3.1.5 Building-integration measures

Support measures through guaranteed feed-in tariffs are mainly geared towards building-integrated applications (BIPV). In France, two types of building integration, IAB and ISB, are taken into account:

- **IAB** – Full building integration: the photovoltaic modules replace the roof elements, provide the main sealing of the building and do not exceed the roof plan by more than 2 cm;
- **ISB** – Simplified building integration: the photovoltaic modules replace the roof elements and are mounted parallel to the roof plan.

The feed-in tariffs in Table 14 show the T1 tariff for BIPV-IAB and the T4 tariff for BIPV-ISB. As for the T5 tariff, it applies to any type of application including building-attached applications (BAPV). In BAPV, PV arrays are fastened onto the construction materials of a building and do not form part of the construction materials.

Building-attached BAPV applications are mainly used in the French overseas regions but their volume remains marginal when compared to the total volume of building integrated applications.

3.1.6 Rural electrification measures

Off-grid PV rural electrification is mostly concentrated in the French overseas departments/regions. These PV systems are financed by FACE – a public fund for rural electrification – by local authorities and by the European Regional Development Fund (FEDER). In 2014, a call for proposals to install hybrid photovoltaic plants in remote off-grid villages of the French overseas region of Guyane led to the construction of six hybrid photovoltaic plants ranging from 50 kW to 150 kW.

3.1.7 Other measures including decentralized storage

In May 2015, the Ministry of Environment issued a call for tenders to install 50 MW of photovoltaic plants (> 100 kW) with storage in non-interconnected insular territories (ZNI territories: Corsica and overseas departments) (see 3.1.2.3).

3.1.8 Support measures phased out in 2015

None of the current support measures were phased out in 2015.

As a reminder, a 50 % income tax credit for private BIPV roof owners was introduced in 2004. It decreased to 22 % in 2011, to 11 % in 2013 and was phased out on 1 January 2014, but the material costs still benefit from a reduced 10 % VAT rate.

3.1.9 New support measures implemented in 2015

The national support measures currently implemented in France are guaranteed feed-in-tariffs and calls for tenders. In order to boost the PV market, the Ministry of Environment took several actions in 2015 by:

- revising the national target volume of PV installations of 5 400 MW for 2020, to 10 200 MW for 2018 and to 18-20 GW for 2023;
- increasing by 10 % the T4 feed-in tariff for PV roofs with simplified building integration;

- launching two calls for tenders, one for rooftop systems (100 kW to 250 kW) for a total volume of 120 MW and the other for the installation of 50 MW of photovoltaic plants (> 100 kW) with storage in non-interconnected territories (ZNI territories);

- increasing the target volumes of two on-going calls for tenders: the first for rooftops, from 120 MW to 240 MW and the second, the CRE 3 call, from 400 MW to 800 MW and then to 1 100 MW;

- publishing a calendar of new calls for tenders for a total power of 4 350 MW between 2016 and 2019.

At regional level, several regional councils launched calls for proposals for self-consumption projects (see 3.1.3).

These national and regional measures were welcomed by the solar industry.

3.1.10 Measures currently discussed but not yet implemented

In 2015, the French government enacted the Energy Transition for Green Growth Act. The Act was voted on by the French Parliament in July 2015 and promulgated in August.

The Act's main objectives include GHG reduction (minus 40 % by 2030 compared to 1990 levels), energy efficiency (reducing energy demand by 50 % by 2050 compared to 2012 levels), the diversification of energy supply through a reduced consumption of nuclear and fossil fuels and an accelerated deployment of renewables (32 % of the final energy consumption and 40 % of the electricity production in 2030).

According to the government, the Act *'embodies a great ambition to make France an exemplary nation in terms of reducing its greenhouse gas emissions, diversifying its energy model and increasing the deployment of renewable energy sources'.*

The Act creates a new support mechanism for renewables over 0,5 MW (starting 1 January 2017), in which electrical energy from renewables will be sold directly on the electricity market and will benefit from a premium based on the difference between the market price and a reference tariff. The involvement of local authorities and private individuals in renewable energy projects will be encouraged. The multi-year energy programme (PPE) will set out the conditions necessary to meet the main energy objectives of the Act.

In 2016, the residential hybrid system PV-T will be eligible to the CITE energy transition tax credit.

The Ministry of Environment announced that fossil fuel use would be taxed and that the resulting revenue would help boost investments in energy efficiency, renewables and transport.

3.1.11 Financing and cost of support measures

The cost of the French PV promotion policy via feed-in tariffs is covered by the Contribution to Electricity Public Services (CSPE). For the year 2015, the PV/CSPE budget amounted to about 2 240 MEUR (source: CRE). The CSPE is a fee paid by electricity customers according to the amount of electricity they consume. In 2015, the fee stood at 19,50 EUR/MWh. The objective of the CSPE is to balance the additional costs borne by electricity operators for their public service mission. Such costs include the additional expenses incurred to ensure equal electricity rates for all French citizens (including overseas departments), specific pricing for people facing financial difficulties, and also the support measures for renewable energies and cogeneration.

Significant financial measures have been taken in support of the Energy transition. The Caisse des dépôts savings fund that finances key projects in the local public sector, has been increased by 5 billion euros, Bpifrance loans have been doubled and the Energy transition financing fund (*Fonds de financement de la Transition énergétique*) has been raised to 1,5 billion euros.

3.2 Indirect policy issues

National/regional indirect initiatives have a favourable impact on the development and the implementation of PV power applications in France and particularly in the regions which are important vectors in speeding up the implementation of renewable energy. The Ministry of Environment launched a call for projects 'Positive-energy regions for green growth' to accelerate concrete actions contributing to Energy transition. At the beginning of 2015, 260 local authorities were selected to receive support from the Energy transition financing fund.

3.2.1 International policies affecting the use of PV power systems

3.2.1.1 COP21

In December 2015, the French government hosted the UN Conference on Climate Change (COP21) in Paris, a major event attracting 20 000 delegates. The leaders of the 195 countries in attendance adopted the Paris Agreement to limit average global warming to well below 2 °C before the end of the century. On 22 April 2016, the Paris Agreement was signed in the UN headquarters by 177 representatives of Parties.

Several significant initiatives arose from various events in parallel with the Paris COP21 Conference. The most noticeable being:

- India and France launched an international solar energy alliance called ISA to boost solar energy in developing countries and its headquarters were soon after inaugurated in New Delhi by the French President and India's Prime Minister;
- The 'Mission Innovation', launched by the French President, the US President and influential entrepreneurs, should lead to a significant increase in public and private investment in clean energy. 19 States committed themselves to doubling the R&D budget within the next five years;
- The 'Paris City Hall Declaration', which aims at implementing energy transition measures towards 100 % renewables, was signed by the Mayor of Paris and one thousand mayors and local government officials representing 600 million people worldwide;
- 'Terrawatt Initiative' (TWI), a non-profit organization, was set up by private entrepreneurs and financiers to promote competitive solar energy and cooperation with ISA, the International Solar Alliance. The TWI Secretariat is handled by Solairedirect, a French company based in Paris;
- 'The Climate Challenge and African Solutions' and 'Carbon Pricing Leadership Coalition' are two initiatives among many others.

3.2.1.2 International and regional activities

Some International organizations such as IEC, CENELEC and IEA play an important role in promoting confidence in PV technology and its applications. IEC and its European equivalent CENELEC develop PV Standards, while IEA focuses on both technical and market studies. The French Agency ADEME has contributed in setting up the TC 82 Technical Committee (Solar Energy Systems) of the International Electrotechnical Commission (IEC), as well as the PV Power systems cooperation programme of the International Energy Agency (IEA).

AFNOR, the French National Standardization Body, takes part in the work of IEC/TC 82 and CENELEC/TC 82, while French experts participate in the current studies of the IEA PVPS programme (Tasks 1, 9, 12, 13 and the new Task 15).

For its part, the European Union plays a leading role in developing PV technologies and markets through its Research and innovation programme (Horizon 2020), its Energy Directives and financing tools (European Regional Development Fund, EIB, EBRD).

On a more regional basis, the Franco-German Renewable Energies Office *(Office franco-allemand pour les énergies renouvelables*) fosters synergies and the exchange of professional experience. In this context, some workshops have been organized on such topics as 'Financial aspects of ground-mounted PV plants' and 'Environmental impact of PV installations'.

3.2.2 Introduction of favourable environmental regulations

The National low-carbon strategy (SNBC), introduced by the Energy Transition for Green Growth Act, outlines the approach to be adopted towards a reduction of greenhouse gas emissions. The carbon budgets, about to be published, will be broken down into major sectors of activity. The climate-energy contribution (carbon tax), fixed at 14,50 EUR/t in 2015 and 22 EUR/t in 2016, should reach 56 EUR/t in 2020 and 100 EUR/t in 2030.

Thermal regulation (RT) applied to buildings, offers new opportunities for the development of the solar market in France. The 'RT 2012' sets the maximum primary energy consumption level for new buildings at 50 kWh/m² per year. It is a milestone towards thermal regulation 'RT 2020', the so-called BEPOS (positive-energy building), under which new buildings will be net producers of energy.

3.2.3 National policies to promote the use of PV in foreign non-IEA countries

Institutional operators such as Business France (formerly Ubifrance), Coface (export credit insurance), Bpifrance Export and the Ministry for the Economy and Finance (Treasury Directorate) provide assistance to French companies wishing to develop abroad, through their financial aid tools and export guarantees. The French Development Agency (AFD Group, *Agence Française de Développement*) finances projects on energy efficiency and renewables in developing countries and the French overseas territories.

The label 'France Solar Industry' is a brand of the French Renewable Energies professional Organization (SER). The label provides the French industry and more particularly SME-SMIs with some promotional support on the international market.

Several cooperation projects involve countries of the south side of the Mediterranean. Such projects are:

- MEDENER, the Mediterranean Association of National Agencies for the development of energy efficiency and renewable energy, along with ADEME as an active member, implements energy-related and environmental strategies. For instance, the MEDCOP initiative was launched in June 2015. Its 36 concrete actions aim at facilitating the Energy transition and limiting the impact of climate change on Mediterranean countries;

- IMEDER, the Mediterranean Institute for Renewable Energy, is a group of professional organizations involved in setting up a variety of conferences and exhibitions;

- SOMED, the network of Mediterranean countries, exchanges information and expertise on solar energy and its applications. INES coordinates the activities of the network and organizes workshops such as the 2nd meeting in Oran, Algeria, in conjunction with the exhibition ERA 2015 on renewables, clean energies and sustainable development (26-28 October 2015).

4 R&D AND BUDGETS

4.1 Highlights of R&D

4.1.1 Agencies

The French policy of research, development and innovation is implemented through three government agencies: ADEME (French Environment and Energy Management Agency), ANR (French National Research Agency) and Bpifrance (French public Investment Bank). Research activities range from upstream studies (ANR's programme) to finalized projects (PV programme from ADEME) and industrial prototypes (re-industrialization support programme of Bpifrance).

Research, development and innovation (RDI) activities cover the full spectrum of topics: performance enhancement, energy cost reduction, quality assurance, long term reliability and electricity grid integration.

ADEME

The 2014-2020 RDI strategy of ADEME aims at accompanying the energy and environmental transitions. In 2015, ADEME launched several calls for proposals (AAP) within the Investments for the Future Programme (*Programme d'Investissements d'avenir*, PIA):

- ENR call for renewable energies is designed to back up the development of new projects. Chapter 2 of this call covers advanced PV modules, innovative processes and equipment for manufacturing materials, cells and modules. It also deals with the experimentation and validation of original photovoltaic systems and building integration technologies;
- PME Initiative, a call directed towards SMEs, provides funding for R&D projects to accelerate the development of methodologies, technologies, services and innovative solutions in the field of renewables;
- IA ROU (roads of the future) includes energy production on road infrastructures with PV modules specifically developed for that purpose;
- AMISYSINT refers to smart electric systems and includes research studies on the integration of distributed renewables into the grid;
- APRED covers R&D on sustainable energies.

ADEME currently manages 13 RDI projects (2014-2015) whose financial support comes either from the PIA programme or from its own research funds. Each year, ADEME grants one or two PhD fellowships. Five new projects under private-public partnerships were selected in 2015: smart module with micro-inverter, bifacial cells and a project on new cell architecture, atmospheric processes for cells, clay PV tiles and module pathology.

ADEME is also involved in the co-funding of projects carried out by two European transnational ERA-NET networks: Solar (see below) and Smart Grids Plus.

ANR, the French National Research Agency, promotes nine societal research challenges within the National Strategic Agenda. Among them, Challenge number 2 'Clean, secure and efficient energy', provides support to basic PV research. In 2015, the annual ANR call for proposals selected six new basic research projects on perovskites, nanowires and a new type of transparent electrode. Altogether, ANR is currently in charge of a dozen PV research projects.

Bpifrance, an organization providing support to small and medium enterprises, manages the Single Interministerial Fund (FUI). Calls for proposals are launched on a semi-annual basis

and specifically targeted at SME-SMI innovation projects. Six PV industrial projects are currently under way.

4.1.2 PV research teams

In France, photovoltaics researchers are part of specialized entities of the national organizations CNRS and CEA. Some researchers are members either of the joint research institute INES, or of the mixed public-private institute IPVF/IRDEP.

Moreover, a number of universities and engineering schools host PV research teams as for instance: GeePs (LGEP), Gif/Paris; ICube, Strasbourg; ILV, Versailles; IMN2P, Marseille; INL, Lyon; LPICM, Saclay/Paris and SIMaP, Grenoble. These teams are often composed of university researchers and personnel seconded from the CNRS.

About 40 research teams and most manufacturers of PV materials, components and machinery, are involved in RDI programmes under private–public partnerships. A number of innovation projects on PV systems and components are also carried out by companies selected through CRE calls for tenders.

INES, the National Solar Energy Institute associates research staff from the CEA, the CNRS, as well as from the University of Savoie, and the CSTB. INES is the main organization in charge of RDI and training on solar energy. Its PV activity covers crystalline silicon (from feedstock to cells), organic materials, PV modules, PV components and systems along with storage and positive energy buildings. The institute is also carrying out studies into solar mobility. The Training & Evaluation Division is currently preparing e-learning PV courses.

IPVF, the Photovoltaic Institute of Île-de-France (IPVF) associates several public research teams and industry laboratories in order to carry out further research into thin film materials, processes and machinery, and to develop advanced concepts for high efficiency cells and modules. The construction of the new IPVF building on the Research Campus of Paris-Saclay is currently under completion.

At European level, French research teams also have the opportunity to cooperate with their European colleagues within two programmes SOLAR-ERA.NET and HORIZON 2020.

- SOLAR-ERA.NET is a network of national and regional funding agencies of the European Research Area. ADEME, as a member of the network, contributes to its financial resources which are pooled together to support transnational private-public targeted projects. The fourth set of transnational calls PV4 and CSP4 was launched on 8 December 2015.

- HORIZON 2020 is the European Union programme of Research and Innovation fully described on their website.

In 2015, the French research community participated in two events of national significance:

- From 1 to 3 July 2015, in Perpignan, the competitiveness cluster DERBI and the Federation for Research on Solar Energy (FédEsol)/CNRS worked together to host the 9th International DERBI Conference and the 2nd JNES Congress (National Solar Energy Days) with the view to facilitate interaction between the scientific and industrial communities. The conference brought together some 330 experts from industry, academia and national/local authorities;
- From 1 to 4 December 2015, in Dourdan near Paris, the 5th Photovoltaic National Days (JNPV), organized by the CNRS, the Federation of PV Research Labs (FedPV) and ADEME gave 170 PV researchers the opportunity to present and discuss their work on many aspects of PV cell materials and characterization tools.

4.2 Public budgets for R&D

Research, development and innovation (RDI) projects are financed through subsidies and/or repayable advances. The sources of national funding come from the Investments for the Future Programme (*Programme d'Investissements d'avenir, PIA*), the Single Interministerial Fund (FUI) and the proper research budgets of governmental agencies.

ADEME, ANR and Bpifrance (French public Investment Bank) operate calls for proposals under the PIA programme and their own resources. The FUI funded projects managed by Bpifrance are to be backed by Competitiveness clusters such as Derbi or Tenerrdis. Regional councils can also provide financial support to collaborative innovation projects.

The public research organizations CNRS, CEA and universities, contribute financially to research projects through their staff salaries and the operating costs of their laboratories. These contributions are not included in the national public intervention budgets of Table 17.

Table 17 – Public budgets for PV RDI 2015 (10^6 EUR)

Public organization	Budget
Intervention budgets of national Agencies: ADEME, ANR and Bpifrance.	3 MEUR

The budget for market stimulation is not public-funded (see 3.1.11).

5 INDUSTRY

All professions are represented in the French photovoltaic value chain. In the most upstream sector, there are companies manufacturing silicon ingots, wafers, cells and modules and companies building and developing production machinery and equipment. A number of companies, some of them belonging to large groups, offer a wide range of industrial materials. BOS components, such as inverters, cables, instruments of control, structure components, solar trackers, etc. are also taken into account. The downstream sector of the value chain covers all implementation activities such as design, component integration, construction, operation, maintenance, material recycling, etc.

This section focuses on PV materials and components developed and manufactured in France.

5.1 Production of feedstocks, ingots and wafers (crystalline silicon)

5.1.1 Feedstock silicon

There is no industrial production of silicon feedstock in France but two companies are currently involved in the development of photovoltaic solar grade silicon through metallurgical methods (as opposed to the traditional chemical method):

- **Ferropem**/FerroAtlántica is collaborating with Apollon Solar, INES and SIMAP/CNRS on the development of a pilot production (Photosil) of 300 t per year. Its main features are the extraction of boron traces by inductive plasma torch followed by directional solidification to elaborate silicon ingots. The objective is to reduce production costs (project funded by ADEME);
- **Emix** Company, a subsidiary of FerroAtlántica, specialized in electromagnetic cold crucible casting, is participating in a Spanish project on solar PV metallurgical grade silicon.

5.1.2 Ingots and wafers

In France, three companies are active in the field of crystalline silicon ingots and wafers: Photowatt, ECM and S'Tile.

- **Photowatt**/EDF ENR PWT is a long-standing vertically integrated manufacturer, founded in 1979 and owned by EDF ENR since March 2012. The company pioneered the crystalline silicon sector using a process of directional solidification to produce large-grain multicrystalline ingots and more recently quasi-monocrystalline ingots. The ingots are rectangular or square-shaped and weigh 400 kg to 600 kg. The annual production capacity of ingots is equivalent to 100 MW. The silicon ingots are sliced into thin square wafers (thickness < 200 µm and area of 243 cm²) through wire saws. The technique for slicing ingots through a wire saw was initiated by Photowatt in collaboration with a Swiss company. This technique is now largely used in industry. The annual slicing capacity is equivalent to 100 MW. Photowatt, in partnership with ECM Technologies, introduced the manufacturing of quasi-monocrystalline silicon ingots. The company also manufactures cells and modules (see 5.2.1, 5.2.3);
- **ECM Technologies** develops and markets crystallization furnaces to produce multicrystalline and quasi-monocrystalline (CrystalMax®) silicon ingots in the 450 kg-800 kg range. The company based in Grenoble, works in partnership with Photowatt, CEA-INES and other research teams of the Rhône-Alpes area;
- **S'Tile** proposes an alternative approach to making silicon wafers without slicing ingots. The company is developing a pilot line to manufacture silicon substrates by sintering metallurgical grade silicon powder, as well as a new process to inter-connect thin crystalline silicon cells (see 5.2.1).

Table 18 – Production information for silicon feedstock, ingot and wafer producers

Manufacturers	Process & technology	Production capacity
- Ferropem/FerroAtlántica (pilot production)	Silicon feedstock (solar PV grade) by metallurgical route	Pilot 300 tonnes/year
- Photowatt/EDF ENR PWT	Ingots by directional solidification; multicrystalline (mc-Si) and quasi-monocrystalline (qc-Si)	100 MW equivalent
- Photowatt/EDF ENR PWT	Thin wafers (200 µm) sliced with wire-saw	100 MW equivalent
- S'Tile (pilot production)	Sintered silicon substrates	Pilot 15 MW/year

5.2 Production of photovoltaic cells and modules

The Photovoltaic module manufacturers based in France produce a full range of PV modules. There is only one producer of PV crystalline silicon cells. Table 19 indicates the annual cell and module production capacity, and their cell technology.

Table 19 – Photovoltaic cell and module production capacity 2015

Cell/Module manufacturer	Technology	Production capacity (MW/y)	
		Cell	Module
Wafer-based PV manufacturers sc-Si: mono-crystalline silicon; mc-Si: multicrystalline silicon; qc-Si: quasi-monocrystalline silicon			
Cell manufacturer - Photowatt/EDF ENR PWT	mc-Si, qc-Si	100	(see below)
Standard module manufacturers - Fonroche Énergie - Francewatts - Photowatt/EDF ENR PWT - SCNAsolar - Sillia VL - Sunpower/Total Group - Systovi - VMH Énergies - Voltec Solar	sc-Si, mc-Si, qc-Si	_	650
Total		**100 MW**	**650 MW**
Thin film manufacturers			
- Nexcis (pilot production)	CIGS Electrodeposition	-	-
- Solems (small-energy applications)	a-Si:H PECVD	-	-

SOURCE: SER, ADEME.

5.2.1 Crystalline silicon PV cells

Photowatt/EDF ENR PWT, as mentioned in 5.1.2, is a vertically integrated manufacturer of crystalline silicon materials. PV cells are prepared from thin wafers (< 200 µm) sliced from silicon ingots. The cell production capacity of the company is 100 MW per year. Standard silicon cells are p-n junction, sized 156 mm × 156 mm. Photowatt produces two types of silicon cells : multicrystalline and quasi-monocrystalline. The conversion efficiency of quasi-monocrystalline cells is half way between multicrystalline and monocrystalline. The company participates in several collaborative R&D projects on crystalline silicon in order to increase cell efficiency and reduce production costs. A pilot line is operated for testing new cell processes.

S'Tile develops a 15 MW pilot line for silicon cells based on their proprietary sintered silicon substrates (see 5.1.2). The 'i-Cells®', are made by connecting thin monocrystalline silicon layers on the low-cost silicon substrates.

5.2.2 Concentrator photovoltaic cells

Soitec SA develops multijunction photovoltaic cells GaInP/GaInAs/Ge with proprietary technologies from microelectronics. A quadruple junction cell reached a record conversion efficiency of 46 %. Its partners German ISE and CEA-LETI share the objective of 50 % efficiency.

5.2.3 Photovoltaic modules

Table 19 lists the PV module manufacturers operating in 2015 with a production facility located in France.

5.2.3.1 Crystalline silicon PV modules

Nine manufacturers produce flat plate PV modules through cell encapsulation. Their annual module production capacity is around 650 MW. Two companies have pioneered module production in France and changed ownership over the years: Photowatt/EDF ENR PWT and Tenesol/Sunpower.

Photowatt manufactures PV modules with their own crystalline silicon cells (see 5.1 and 5.2.1) in Vaulx-Milieu (Isère), a factory situated near Bourgoin-Jallieu where ingot/wafer/cell production is carried out.

Sunpower (Total Group subsidiary) has taken over Tenesol, a PV module manufacturer located in Toulouse. A smaller factory in Porcelette (Total Group), manufactures modules from PV laminates. The modules use single-crystal silicon back-contact cells manufactured by Sunpower in Malaysia and the Philippines. The company Sunpower also runs two module factories in the Philippines and Mexico.

Between 2008 and 2010, several companies started manufacturing photovoltaic modules based on imported crystalline silicon cells, but some of them ceased activity after two or three years of production.

The companies with standard module production capacity greater than 50 MW/y are, in alphabetical order: Fonroche Energie, Photowatt, Sillia VL, Sunpower and Voltec Solar. Sillia VL is the French company with the highest production capacity (factories in Lannion and Vénissieux).

Overall, French companies manufacture a wide range of photovoltaic products from standard modules to modules specifically adapted to building integration and architectural elements. Other companies, Luxol and Captelia (Imerys Toiture), manufacture PV tiles (size 45 cm × 31 cm and 136 cm × 50 cm respectively), while DualSun and Systovi develop and market photovoltaic-thermal hybrid modules (PV-T).

5.2.3.2 Thin film modules

There is no large-scale industrial production of thin film modules for power applications in France. Solems is the only manufacturer of amorphous silicon modules designed for small power applications.

Nexcis is working on the development of a pilot line of CIGS-based modules. The technique involves the electrodeposition of copper, indium and gallium, coupled with annealing in a sulfur and selenium atmosphere.

The entry of photovoltaic organic materials (OPV) onto the electrical energy market still requires further development. Armor SA is developing printing techniques adapted to thin film OPV technology.

5.2.4 Solar trackers

Exosun, Optimum Tracker and HéliosLite supply solar tracking technologies (single-axis and dual axis) for utility-scale PV plants. The companies participate in several projects selected by CRE calls and in a number of projects abroad.

5.2.5 PV product recycling

With the implementation of the WEEE (Waste Electrical and Electronic Equipment) legislation, PV waste management has become a legally-binding requirement for PV module importers or manufacturers. PV CYCLE France SAS was founded in 2014 by several PV players to offer waste management solutions to the French industry.

5.3 Other components

In the most upstream part of the field, some companies produce the machine tools and equipment needed for the production of silicon ingots, wafers, cells, and solar materials (gas,

specialty glass, polymers, graphite, ceramics...). Some of these groups hold leading positions in their own specific fields.

Many major French companies supply a full range of electrical materials and equipment used in the connection, conversion, control, measurement and monitoring of photovoltaic systems. Several French companies have developed several types of inverters. Many of these companies are actors both on the domestic and export markets.

The feed-in tariffs granted to building integration have encouraged companies to develop specific components. A number of firms manufacture and supply building-integration products (IAB and ISB), and can apply for technical assessment certificates such as ATec PV/CSTB, Pass'Innovation Vert/CSTB or ETN (New technique assessment).

Solar PV carports for car parks represent a growing market segment that has led to designing new types of structures, and some companies have made it their core business.

The downstream sector of the industry counts about a thousand installation companies holding the quality label QualiPV-RGE, drawn up by professional bodies.

6 PHOTOVOLTAICS IN THE ECONOMY

6.1 Labour places

According to a study carried out for ADEME [9], the total number of direct full-time equivalent (FTE) jobs in component manufacturing, engineering studies, installation, and operation/maintenance, was estimated at 7 400 in 2015 (Table 20).

The variations in employment over the years are directly related to the activity in the installation, operation and maintenance sectors, which are the main sources of PV jobs.

The number of public PV R&D positions in the CNRS, the CEA, PV Institutes, universities and engineering schools is relatively stable with 900 FTEs.

Table 20 – Estimated PV-related labour places in 2015 (FTE)

Segment	Direct FTE
Public research and development (not including companies)	900
Manufacturing of products throughout the PV value chain from materials to systems, distributors of PV products, system and installation companies, electricity businesses.	7 400

SOURCE: ADEME [9] (provisional). CNRS/Cellule Énergie.

6.2 Business value

Investments in PV installations in France were estimated at 1,24 billion euros for the year 2015 (source ADEME [9]).

7 INTEREST FROM ELECTRICITY STAKEHOLDERS

7.1 Structure of the electricity system

Since 1 July 2007, production, trade and supply have been open to competition, while transmission and distribution have remained regulated businesses. The Public authorities, the French Regulatory Commission of Energy (CRE) and the Competition Authority all supervise the application of the new market regulations.

The electricity distribution grids belong to local authorities (French municipalities or groups of municipalities), who subcontract the management and operation to ERDF/ENEDIS (95 % of the grid of continental France) or to local distribution companies (ELD, 5 %) through public service delegation. ERDF (newly named ENEDIS), a subsidiary of EDF, is a distribution grid operator created on 1 January 2008. RTE (*Réseau de transport d'électricité*), which is also a subsidiary of EDF, is responsible for the HVB high voltage transmission of electricity. The companies are currently exploring different options in order to reduce the integration costs of renewables into the distribution grids and are also seeking new solutions.

The TURPE tariff, paid by electricity consumers, has been introduced to fund distribution businesses and allow them to maintain and upgrade the grid so as to include renewables.

7.2 Interest from electricity utility businesses

The two major energy companies EDF and ENGIE, along with their subsidiaries, are involved in the deployment of renewables. Some smaller companies have been set up to develop and operate renewable energy power plants.

7.2.1 EDF Group

EDF EN (EDF Énergies Nouvelles) created in 1990, is a subsidiary of the French energy company EDF. EDF EN develops, builds and operates renewable electricity plants worldwide (total 9 GW). The installed PV capacity in France is around 300 MW. The subsidiary EDF EN Services is specialized in the operation and maintenance of power plants.

EDF ENR (EDF Énergies Nouvelles Réparties) is an EDF EN subsidiary created in 2007. Along with its two subsidiaries EDF ENR Solaire and EDF ENR PWT (Photowatt), EDF ENR is the only French company present throughout the PV value chain including R&D:

- EDF ENR Solaire provides PV installations for individual housing, agricultural, industrial and administrative buildings, as well as supervision and maintenance for around 15 000 residential installations. The company also commercializes residential BAPV systems operated in full self-consumption mode;
- EDF ENR PWT (Photowatt) manufactures crystalline silicon ingots, wafers, cells and PV modules (see 5.1 and 5.2).

7.2.2 ENGIE Group

ENGIE (formerly known as GDF SUEZ) operates 383 MW of PV capacity in France with its subsidiaries, La Compagnie du Vent, La Compagnie Nationale du Rhône, Futures Énergies and Solairedirect. In July 2015, ENGIE acquired a 95 % stake in Solairedirect, a French PV company with an international reach.

7.2.3 Other companies and RE producers

In addition to the main energy companies and their subsidiaries, there is a very active network of developers, builders and operators. In recent years, independent renewable energy producers have installed numerous photovoltaic power plants.

7.3 Interest from local authorities

In 2012/2014, the regional authorities drew up some provisional programmes on energy, air and climate (SRCAE), planning around 43 GW of renewables for 2020. The regional schemes related to renewable energy grid-connection (S3REnR), aim at adapting and improving the electricity grid in accordance with the objectives of SRCAE.

The website capareseau.fr (RTE and ERDF/ENEDIS) provides information on the status of regional schemes and on the capacity of the grids to accommodate renewable electricity generation.

The regional and departmental authorities, in partnership with ADEME, have focused their support policies on the development of self-consumption PV projects and collaborative citizens' initiatives (see 3.1.3).

More and more municipalities are also active in implementing innovative policies in the sector of renewables and energy efficiency.

8 STANDARDS AND CODES

8.1 Standards

AFNOR represents France in standardization bodies on the European level (CEN and CENELEC) as well as on the international level (ISO and IEC).

France does not develop its own standards for PV components but implements those prepared by IEC and CENELEC. The French National PV standardization committee AFNOR/UF 82 and its 29 experts participate in the vote of acceptance of International Standards, after comments and amendments. IEC and CENELEC require that International Standards be translated into French. French versions are incorporated into the French NF Standard system and display the NF EN prefix as in NF EN 61215. International references such as IEC 61215 are also accepted in the specifications of calls for tenders.

PV systems and PV installations comply with technical documents drawn up by the AFNOR/U15 committee. Among them, the newly published specification *Photovoltaic systems with storage and connected to the public distribution grid* (AFNOR XP C 15-712-3), complementing the recently updated technical specifications: *Photovoltaic systems without storage and connected to the public distribution grid* (AFNOR/UTE C 15-712-1) and *Stand-alone photovoltaic systems with storage* and *not connected to the public grid* (AFNOR/UTE C 15-712-2).

8.2 Technical guides

Many technical guides look into the multiple aspects of PV implementation. For example**:** *Managing risk in photovoltaic installations* (GIMELEC/SER/ADEME); *What should I do in case of destruction or dismantling of my installation?* (EDF OA); *Drafting contractual documents, Performance and energy consumption*, *Rules of conduct of PV in the building sector* (Building Federation); *Guide for connecting a PV installation up to 36 kVA* (ERDF); *Administrative, budget and tax management for inter-municipal PV projects* (CRER Poitou-Charentes) and *Photovoltaics and Territorial Collectivities* (ADEME).

8.3 Qualification and certification

Certisolis TC is the only laboratory in France certifying PV modules. The Certisolis MPV label not only guarantees the modules conformity with applicable Standards, but also indicates that the modules undergo an annual quality audit on their design and manufacture.

Certisolis carries out quality controls of PV modules following reception on the installation site.

The CSTB (Scientific and Technical Centre for Construction) has set up a technical assessment procedure to ensure that photovoltaic products and processes used on a building would be covered by basic insurance contracts. The Photovoltaic technical assessments (Atec PV) are awarded for a maximum period of 3 years. CSTB's '*Pass Innovation Vert*' is an

optional step before starting the Technical assessment procedure. It is valid for a maximum period of 2 years.

To meet insurance requirements, some products and processes used in the PV building sector can also be evaluated through a New Technique Assessment (ETN). An ETN (*Enquête de Technique Nouvelle*) is issued by a registered inspector according to the information provided by the manufacturer.

Professional associations and administrative authorities have developed a range of recommendations and quality labels to promote products and service quality. Qualit'EnR is a certified association specialized in the qualification of renewable energy businesses. The Qualit'EnR/QualiPV label comes in two versions: *QualiPV Elec* for electricians and *QualiPV Bât* for roofers. Companies in the construction and energy sectors can use other quality labels such as Qualibat (EE/ENR), Qualifelec (SPV) or Opqibi. Once accepted by the public authorities and ADEME, these quality labels display the acronym RGE (*Reconnu garant de l'environnement*). Homeowners wishing to benefit from a public subsidy have to call on qualified professionals carrying the RGE quality label and complying with the mandatory ten-year liability requirements.

The Alliance for Photovoltaic Quality (AQPV, *Alliance Qualité Photovoltaïque*) is a quality label awarded by SER. It certifies the quality of PV modules (AQPV-Modules) and of operator services (AQPV-General Contractor).

9 HIGHLIGHTS AND PROSPECTS

In 2015, French wind and solar photovoltaic production capacity increased by 26 %, with 932 MW of wind and 887 MW of photovoltaics. At the end of the year, French cumulative wind capacity amounted to 10 308 MW and photovoltaic cumulative capacity to 6 559 MW.

During the year, the French government promulgated the Energy Transition for Green Growth Act and took several measures in favour of the photovoltaic sector. Moreover, political authorities attended a number of events in research institutes, industry facilities and field applications.

The Ministry of Environment added 820 MW to the target volumes of the two on-going calls for tenders, increased by 10 % the T4 feed-in tariff for rooftops with simplified-building integration and launched two calls for tenders, one for rooftop systems and the other for the installation of photovoltaic plants with storage in non-interconnected territories. The Ministry also published a three-year calendar of new calls for tenders totalling 4,35 GW.

In parallel with national support policies, several Regional councils issued calls for proposals on self-consumption projects.

All these measures were welcomed by the solar industry.

The Energy Transition for Green Growth Act was promulgated by the French Parliament in August 2015. The law creates a new support mechanism for renewables over 0,5 MW (starting 1 January 2017)**,** in which electrical energy will be sold directly on the electricity market and will benefit from a premium.

The UN Conference on Climate Change (COP21) took place in Paris in December 2015. The leaders of the 195 countries in attendance adopted the Paris Agreement. Though renewables were not on the priority list, a few side events were favourable to the PV sector, as for instance, the launch by India and France of an International Solar Alliance to boost solar energy in developing countries with the target of installing 1 000 GW by 2030.

Prospects

In 2015, the Ministry published a three-year calendar of new photovoltaic calls for tenders totalling 4,35 GW and planned between 18 GW and 20 GW by 2023. The Energy Transition Act targeted 40 % of electricity production from renewables by 2030, and the Agency ADEME presented a prospective study *A 100 % Renewable Electricity Mix? – Analyses and Optimisations 2050*. As for the industry, it maintained the objective of 20 GW by 2020.

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ANNEX A DEFINITIONS, SYMBOLS AND ABBREVIATIONS

Table A.1 - List of French acronyms

Acronym	English	French
ADEME	French Environment and Energy Management Agency	Agence de l'environnement et de la maîtrise de l'énergie
CEA	French Alternative Energies and Atomic Energy Commission	Commissariat à l'énergie atomique et aux énergies alternatives
CNRS	French National Scientific Research Council (covers all scientific disciplines)	Centre national de la recherche scientifique
CRE	French Regulatory Commission of Energy	Commission de régulation de l'énergie
EDF	Electricity of France (electricity company)	Électricité de France
EDF-SEI	EDF - Insular electricity grids	EDF-Systèmes électriques insulaires
ELD	Local electricity distribution company	Entreprise locale de distribution d'électricité
DROM	French overseas departments or regions NOTE - Five DROMs are taken into account in the report: Regions of Guadeloupe, Guyane, La Réunion, Martinique and Department of Mayotte. Regions are composed of several departments. The elected authority is called the Regional council.	Département/région d'outre-mer
ERDF(ENEDIS)	French Electricity Distribution (new name ENEDIS)	Électricité Réseau Distribution France
IAB ISB	Full building integration (BIPV-IAB) Simplified building integration (BIPV-ISB)	Intégration au bâtiment Intégration simplifiée
INES	National Institute for Solar Energy	Institut national pour l'énergie solaire
IPVF	Photovoltaic Institute from Île-de-France	Institut photovoltaïque d'Île de France
MEEM	Ministry of Environment, Energy and Sea NOTE - Formerly named Ministry of Ecology, Sustainable Development and Energy.	Ministère de l'environnement, de l'énergie et de la mer
PPE PPI	Multi-year Energy Programme. Multi-year programme for investment in the power sector (2009, revised in 2015).	Programmation pluriannuelle de l'énergie
RTE	French transmission system operator	Réseau de transport d'électricité
SER	French renewable energies industry association	Syndicat des énergies renouvelables
SOeS	Observation and statistics Office from Ministry of Environment (MEEM)	Service de l'observation et des statistiques (MEEM)
ZNI	Non-interconnected territories (Corsica and overseas departments/regions…)	Zones non interconnectées (Corse et DROM)

For the purposes of this report, the following definitions, symbols and abbreviations apply:
BAPV: building-attached photovoltaic(s). [adj. or noun].
BIPV: building-integrated photovoltaic(s). [adj. or noun].
BIPV-IAB: full building integration (French FIT programme).
BIPV-ISB: simplified building integration (French FIT programme).
FIT: feed-in tariff.
PV: photovoltaics (noun) or photovoltaic (adj.).
STC: standard test conditions.

building-attached photovoltaics (BAPV): concept or application of fastening photovoltaic modules onto the construction materials of a building. The modules do not form part of the construction materials.

building-integrated photovoltaics (BIPV): concept or application of integrating photovoltaic modules into or with the construction materials of a building. The modules may or may not be specifically designed for integration.

building integration (definitions applying to the French FIT programme):

- **full building integration (IAB):** application where the photovoltaic modules replace the roof elements, provide the main sealing of the building and do not exceed the roof plan by more than 2 cm.
  NOTE - The building sealing is not provided by steel sheeting as in the case of ISB.

- **simplified building integration (ISB):** application where the photovoltaic modules replace the roof elements and are mounted parallel to the roof plan.

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