IEA INTERNATIONAL ENERGY AGENCY

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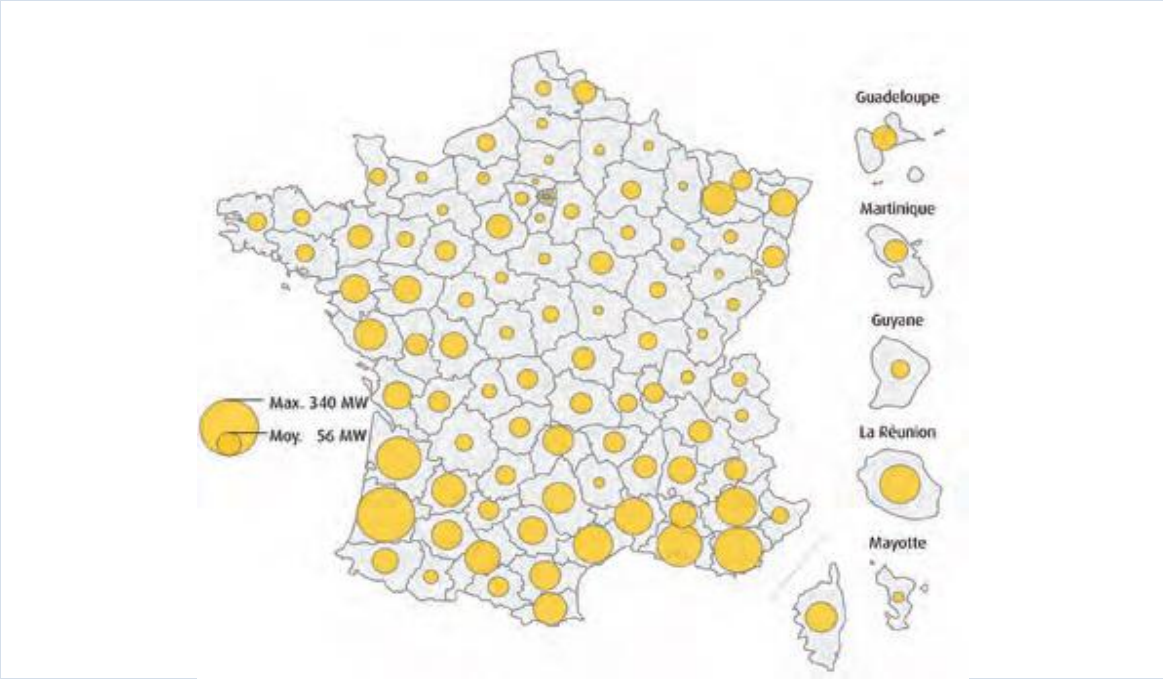
Agence de l'Environnement et de la Maîtrise de l'Energie

National Survey Report of PV Power Applications in FRANCE 2014



PVPS

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

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The French Environment and Energy Management Agency

June 2015

FRONT COVER: Distribution of PV installations in France in 2014 (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 Ecology, Sustainable development and Energy (MEDDE) and the Ministry of Higher Education and Research (MESR).

ADEME participates in the implementation of public policies in the areas of energy and sustainable development. The Agency provides its expertise and advice to companies, public authorities and the general public in support of their environmental initiatives. In addition, ADEME helps finance projects ranging from research to implementation in the areas of waste management, soil conservation, energy efficiency, renewable energies and air quality.

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 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 the active and completed tasks can be found on the IEA-PVPS website.

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 Trends in photovoltaic applications report. 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 2014. 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, reports and studies produced by the professional unions SER and ENERPLAN, reports by the *Observatoire des énergies renouvelables* (Observ'ER), publications by Observ'ER/Systèmes Solaires, 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.

The following studies and reports have proved to be most useful when preparing the report:

- Tableau de bord éolien-photovoltaïque, SOeS, n° 611, February 2015 and n° 644, June 2015;
- Panorama de l'électricité renouvelable 2014, RTE, SER, ERDF and ADEeF, February 2015;
- PV Atlas 2014 des grandes centrales PV > 1 MW, Observ'ER, Journal du photovoltaïque n° 12, November 2014;
- Bilan électrique 2014, (RTE Electricity Report 2014), RTE, January 2015;
- Annuaire du Syndicat des énergies renouvelables 2014, SER, September 2014;
- Contribution de l'ADEME à l'élaboration des visions énergétiques 2030/2050, ADEME, June 2013;
- Photovoltaïque et collectivités territoriales – Guide pour une approche de proximité, ADEME, October 2014;
- Étude de la filière photovoltaïque française – Bilan, perspectives et stratégie, ADEME (study carried out by Care/ECube/In Numeri), unpublished, May 2015.

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 40 W or more. A photovoltaic system consists of PV modules, inverters, batteries and all installation and control components for modules, inverters and batteries. Other applications such as small mobile devices are not considered in this report.

For the purposes of this report, PV installations are included in the statistics if the PV modules were installed and connected to the grid between 1 January and 31 December 2014, although commissioning may have taken place at a later date. The main technical 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 power of a PV module is measured in the manufacturing plant under standard test conditions (STC, 1 $kW \cdot m^{-2}$, 25 °C). 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 electric energy to off-grid sites (remote homes, telecom relays, etc.). Since 2002, with the introduction of feed-in tariffs, PV systems have been increasingly installed for supplying power to the public electricity network (ADEME was funding PV rooftop applications before that date as part of a demonstration programme).

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 2014 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 simply installed in the built environment (power range: kW to MW).

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

- Off-grid PV power system: system installed to provide power mainly to a household or village not connected to the utility 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 (*Service de l'observation et des statistiques*, publications n° 611, February 2015 and n° 644, June 2015). SOeS statistics covering metropolitan France and the overseas departments/regions are those of companies operating electricity distribution and transport: ERDF, RTE, EDF-SEI and local distribution companies (ELD). (www.statistiques.developpement-durable.gouv.fr).

Further data are also available, among which the report 'Overview of renewable electricity in 2014' (*Panorama de l'électricité renouvelable 2014*) published in February 2015 by RTE, SER, ERDF and ADEeF. Volumes are slightly different from those published by the SOeS since they do not include installations in overseas departments/regions.

SOeS breaks down installed power data into different power categories and 27 administrative regions. Data for the installed volume of centralized ground-mounted applications are supplied by the PV Atlas Observ'ER. The PV Atlas published by Systèmes solaires/Le journal du photovoltaïque (November 2014) lists photovoltaic installations with a power over 1 MW.

The volume of distributed applications (residential, industrial, agricultural or commercial roofs, large PV carports, 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

In the report, off-grid data only refer to new installations and not to the replacement of PV modules or to an increase in power for the systems already in place. The off-grid PV business is mainly found in the French overseas departments/regions. Data for rural electrification come from the annual statistics of the Face Fund, but there were not published in 2014.

1.2.2 Photovoltaic power installed in 2014

The photovoltaic grid-connected power installed in France in 2014 (metropolitan and overseas) was estimated at 939 MW compared to 651 MW in 2013, 1 120 MW in 2012 and 1 760 MW in 2011 (source: SOeS). Grid-connected distributed systems, mainly building-integrated applications, reached 601 MW (64 %) and centralized ground-based systems 338 MW (sources: SOeS, PV Atlas Observ'ER and ADEME). Overseas departments/regions (DROM) accounted for 14 MW.

Off-grid applications were estimated at 50 kW in 2014.

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

The global investment linked to the PV installation activity in 2014 is estimated at 1,5 billion euro.

Table 1 – Photovoltaic power installed during the calendar year 2014 (MW)

Sub-market	Application	Power installed
Grid-connected	Distributed (Mainly building integration IAB or ISB)	601 MW (64 %)
	Centralized ground-mounted	338 MW (36 %)
	Sub-total grid-connected	**939** MW
Off-grid	Rural electrification	**0,05** MW

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

Table 2 details grid-connected installations according to different power segments in 2014. There was a 44 % increase in the grid-connected power and an 18 % decrease in the number of installations compared to 2013. The annual growth comes mainly from the installation of systems over 250 kW with 63 % of total power installed within the year. Systems up to 9 kW represent 89 % of the total number of installations. The average power of installations increased from 19 kW in 2013 to 35 kW in 2014.

Table 2 – Grid-connected installed capacity during the calendar year 2014 (MW)

Power segment	Application	Installation number (% of total)	Power (MW) (% of total)
0 – 3 kW	Building integration (IAB)	37,5 %	3,2 %
3 kW – 9 kW	Building integration (IAB)	50,8 %	10,0 %
9 kW – 36 kW	Simplified building integration (ISB)	3,4 %	2,9 %
36 kW – 100 kW	Simplified building integration (ISB)	6,9 %	17,6 %
100 kW – 250 kW	Simplified building integration (ISB)	0,9 %	5,3 %
> 250 kW	Large roofs, ground-mounted plants,…	0,5 %	61,1 %
Total		**28 026** (100 %)	**939 MW** (100 %)

SOURCE: SOeS. Definitions of IAB and ISB are given in 3.1.5.

Figure 1 and Figure 2 show the evolution of installed power 2011-2014 according to various power segments.

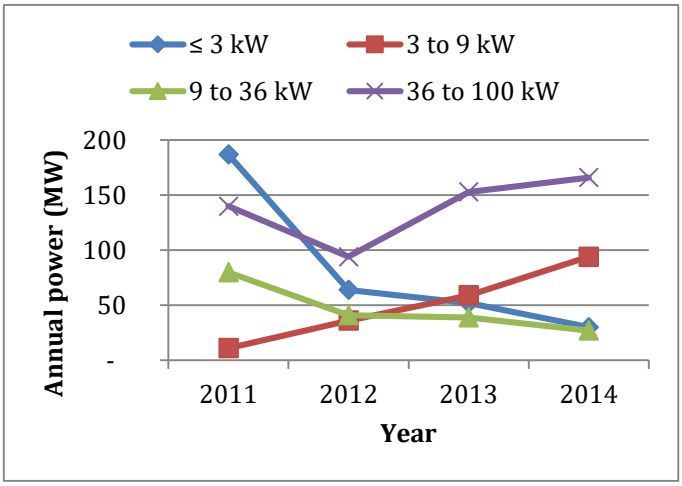

Figure 1 – Installed volume by power segments up to 100 kW 2011-2014

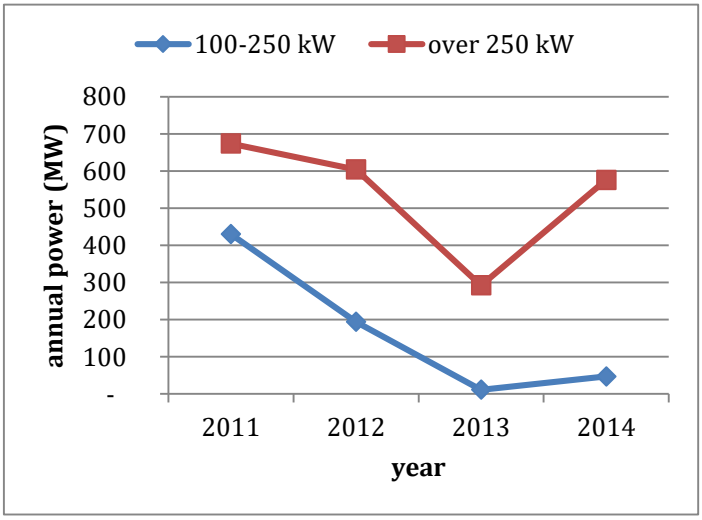

Figure 2 – Installed volume by power segments above 100 kW 2011-2014

1.2.3 Photovoltaic production and the energy market

Table 3 shows PV electricity production in 2014 relating to the electric energy market in metropolitan France (excluding the overseas departments). All data come from the French Electricity Report published by RTE (*Bilan électrique 2014*) and are slightly different from the SOeS statistics. PV electric energy production is estimated at 5,9 TWh, a 27 % increase on

the previous year. Photovoltaic capacity represents 4,1 % of the total national power generation capacity and the annual average load factor is 14 %. PV electric energy production covers 1,3 % of national electric energy consumption. In 2014, 46 % of new electricity generation capacity installed in metropolitan France came from photovoltaic systems installed during the year.

The 'Overview of Renewable Electricity 2014' (*Panorama de l'électricité renouvelable 2014*) published by RTE, SER, ERDF and ADEeF gives a detailed analysis of each administrative region (production, load factor, rate of consumption). The publication indicates that a peak of PV electricity generation was reached at 13:30 on 17 May 2014 with 3 700 MW and that consumption coverage reached a high of 8,6 % at 14:00 on 18 May 2014.

Table 3 – PV power and the broader national energy market

	2014	2013
Total power generation capacities (all technologies)	Total: 128 943 MW of which Nuclear: 63 130 MW; Fossil fuel: 24 411 MW. RES: 41 402 MW (see below)	Total: 128 029 MW of which Nuclear: 63 130 MW; Fossil fuel: 25 576 MW; RES: 39 323 MW (see below)
Total power generation capacities (renewables including hydropower)	**PV***: 5 292 MW **(4,1 %)**; Hydro: 25 411 MW; Wind: 9 120 MW; Other RES: 1 579 MW.	**PV***: 4 298 MW **(3,4 %)**; Hydro: 25 404 MW; Wind: 8 143 MW; Other RES: 1 478 MW.
Total electricity consumption	465 TWh	440 TWh
New power generation capacities installed during the year (all technologies)	Total: 1 990 MW of which Gas: + 9 MW; Coal: - 1 240 MW; Fossil fuel: - 65 MW; Nuclear: 0 MW; PV and other RES: see below.	Total: 1 461 MW of which Gas: - 71 MW; Coal: -1 573 MW; Fossil fuel: - 607 MW; Nuclear: 0 MW; PV and other RES: see below.
New power generation capacities installed during the year (renewables including hydropower)	**PV***: + 927 MW **(46 %);** Wind: + 963 MW (48 %); Hydro: - 23 MW; Other RES: + 92 MW.	**PV***: + 743 MW **(51 %);** Wind: + 630 MW (43 %); Hydro: - 3 MW; Other RES: + 88 MW.
Total PV electricity production	**PV: 5,9 TWh**	**PV: 4,6 TWh**
Total PV electricity production as a % of total electricity consumption	**1,3 %**	**1,0 %**

SOURCE: RTE France Electricity Reports for 2013 and 2014.*RTE provisional PV figures differ from those of SOeS.

Table 4 – Number of PV installations and state of grid connection at the end of 2014

	Number
Total France (grid-connected) - metropolitan France - overseas departments/regions	**346 950** **98,2 %** **1,8 %**
PV capacity connected to the low and medium voltage distribution grid (metropolitan France)	**93,6 %**
PV capacity connected to the high voltage HVB transmission grid (metropolitan France)	**6,4 %**
Capacity of decommissioned PV systems during the year (MW)	**n/a**

SOURCES: SOeS, ERDF, RTE, EDF-SEI, ELD.

To balance supply and demand, RTE has developed a software planning tool called IPES, to estimate the electricity production of renewables. To date, 20 % of PV production has been monitored in real-time thus providing input for the IPES tool.

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 2014 (MW)

Sub-market	Application	Power (MW)
Grid-connected	Distributed (Mainly building-integrated systems)	3 965 MW (70 %)
	Centralized ground-mounted	1 683 MW (30 %)
	Sub-total grid-connected	**5 648 MW** (100 %)
Off-grid	Rural electrification…	**29,75 MW**

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

Table 6 – Grid-connected cumulative installed PV power at the end of 2014

Power segment	Application	Installation number (% of total)	Power (MW) (% of total)
0 – 3 kW	Building integration (IAB)	79,1 %	13,0 %
3 kW – 9 kW	Building integration (IAB)	11,9 %	4,5 %
9 kW – 36 kW	Simplified building integration (ISB)	4,6 %	7,0 %
36 kW – 100 kW	Simplified building integration (ISB)	2,6 %	12,4 %
100 kW – 250 kW	Simplified building integration (ISB)	1,5 %	16,3 %
> 250 kW	Large roofs, ground-mounted plants, …	0,3 %	46,9 %
Total		**346 950 inst.** (100 %)	**5 648 MW** (100 %)

SOURCE: SOeS.

Table 7a – Cumulative installed PV power in 3 sub-markets, 2005-2014 (MW)

Application	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Off-grid	20,0	21,5	22,5	22,9	29,2	29,3	29,4	29,6	29,7	**29,75**
Grid-connected centralized ground-mounted	0	0,0	0,0	7	42	242	702	1 022	1 342	1 680
Grid-connected distributed	5,9	15,3	49	83	299	936	2 236	3 035	3 367	3 968
Grid-connected sub-total	5,9	15,3	49	90	341	1 178	2 938	4 057	4709	**5 648**
Total (MW)	25,9	36,8	71,5	113	370	1 207	2 967	4 087	4 739	5 678

SOURCE: SOeS, previous IEA NSR reports for France. 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, 1992-2004 (MW)

1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
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

SOURCE: ADEME.

Figure 3 shows the evolution of national grid-connected photovoltaic power between 2007 and 2014 (annual installation volume and cumulative capacity at the end of each year).

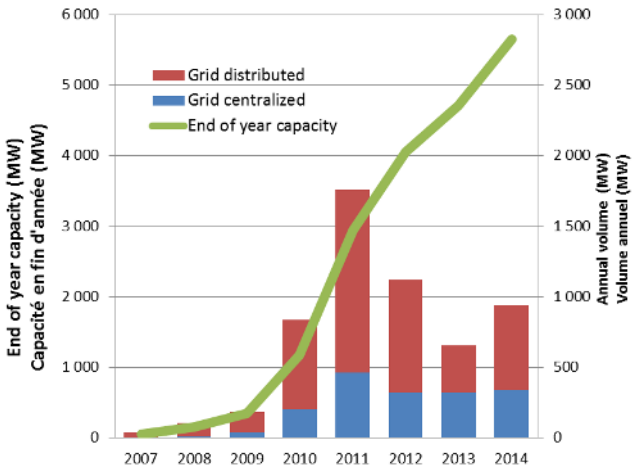

Figure 3 – Annual and cumulative capacity of grid-connected installations in France

The main PV implantation areas in metropolitan France are in the sunniest southern regions. Table 8 shows the six most active regions: they represent 63 % of total capacity and 56 % of the number of installations. In 2014, the annual power installed in these regions was close to three quarters of the power installed in the 22 regions of metropolitan France.

Table 8 – PV installations in French Regions (metropolitan France)

Regions with a power capacity > 300 MW	**Cumulative installed capacity at the end of 2014** (% of metropolitan capacity)	**Installation number** (% of metropolitan number)	**Grid-connected power during 2014** (% of metropolitan power)
Aquitaine	14,5 %	7,7 %	30,7 %
Provence – Alpes – Côte d'Azur	14,5 %	9,4 %	11,7 %
Midi-Pyrénées	10,9 %	6,9 %	8,2 %
Languedoc-Roussillon	10,2 %	7,9 %	11,4 %
Pays de la Loire	6,6 %	11,2 %	6,3 %
Rhône-Alpes	6,3 %	12,9 %	4,6 %
Total for 6 regions	**3 333** MW (63 %)	**190 298** installations (56 %)	**666** MW (72 %)

SOURCE: SOeS, Feb. 2015.

In France, 90 % of installed PV modules are based on crystalline silicon and 10 % are thin films (essentially cadmium telluride for ground-mounted power plants).

French overseas departments/regions (DROM) represent 6 % (341 MW) of total national PV capacity and 1,8 % of the number of installations. The region of Réunion alone accounts for nearly 49 % of installed power capacity in the DROM. A slowdown in the volume of PV installations is to be noted in the overseas departments and in the metropolitan department of Corsica, resulting from the variable energy limitation imposed by the EDF division in charge of insular electricity networks (EDF-SEI). The limitation is set at 30 % of the total power production capacity of the territories. To meet this requirement, the national call for tenders CRE 1 has authorized 50 MW of PV power projects with storage batteries specifically meant for Corsica and the French overseas departments (see 3.1.7).

2 COMPETITIVENESS OF PV ELECTRICITY

2.1 Module prices

Most French standard PV module manufacturers use their products either for their own installation projects or for that of their regular partners. Prices range from 0,55 EUR/W to 0,65 EUR/W (excluding VAT).

2.2 System prices

The average turnkey price of installed building-integrated residential systems with European modules (IAB) is around 3,5 EUR/W. Simplified integrated installations (ISB) on commercial buildings stand at 1,6 EUR/W. The average turnkey price for ground-mounted plants is about 1,3 EUR/W (all prices indicated are exclusive of VAT). Some turnkey prices of typical applications are shown in Table 9 and Table 10 (source: unpublished BIPS study for ADEME).

Table 9 – Turnkey prices of typical applications (EUR/W) 2014

Category/Size	Typical applications	Price range
Grid-connected IAB roof up to 3 kW	Residential building integration new buildings - existing buildings	3,0-4,0 EUR/W
Grid-connected ISB roof < 36 kVA	Simplified building integration new buildings-existing buildings	2,1-2,4 EUR/W
Grid-connected ISB roof 100 kW to 250 kW	Industrial, commercial, agricultural large roof new buildings-existing buildings	1,5-1,7 EUR/W
Grid-connected ground-mounted > 1 MW	Centralized production, utility-scale plant Fixed-with trackers	1,2-1,4 EUR/W

SOURCE: ADEME-BIPS. *VAT not included.

Table 10 – National trends in average system prices (EUR/W)

Application	2007	2008	2009	2010	2011	2012	2013	2014
Residential IAB roof 3 kW existing building	8,4	8,2	6,9	5,9	3,9	3,7	3,6	3,5
Large commercial ISB roof > 100 kW	7,8	7,6	6,4	5,5	2,6	2,0	1,8	1,6
Centralized ground-mounted > 1 MW	6,3	6,2	5,2	4,5	2,0	1,6	1,5	1,25

SOURCE: ADEME. VAT not included.

2.3 Financial parameters and programmes

The wide scope of grid-connected applications from residential PV roofs to large PV roofs and ground-mounted utility-scale plants requires the deployment of specific financing tools.

Local authorities are increasingly developing policies to promote renewables. To help them reach this objective, ADEME published a new photovoltaic guide (Photovoltaics and territorial collectivities) in October 2014. The guide goes into various modes of financing from supply of equity to European Structural Funds. Some innovative financing options such as third-party funding, venture capital financing and crowdfunding are also mentioned.

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

Some companies install PV systems on commercial/industrial rooftops that are leased by building owners who receive monthly payments.

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 is the long-term lending bank of the European Union and its contribution can represent up to 50 % of the total financing of the project. The ‘EU bank’ supports the development of EU policies including the deployment of renewable energies.

2.4 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

Country parameters, population, size	France = Metropolitan France (continental France + Corsica Island), 22 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.
Retail electricity prices: household, commercial company, industrial company	Household: 0,144 EUR_{TTC}/kWh; Commercial: 0,036 to 0,093 EUR_{HT}/kWh; Industry: 0,0289 to 0,0777 EUR_{HT}/kWh.
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 electric utilities.	EDF SA (Électricité de France): 100 GW; GDF-SUEZ: 10 GW; E.ON France: 3,3 GW…
Transmission	RTE (Réseau de transport d'électricité).
Distribution	ERDF, 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 Sorégies…

3 POLICY FRAMEWORK

The development of photovoltaic applications in France has mostly been driven by National and Regional support policies. Since the 1980s, a number of direct support measures have been taken towards the electrification of off-grid sites and, since 2002, towards the grid-connected power supply. Some indirect support policies have also had a favourable impact on PV development.

3.1 Direct support measures

Table 12 summarizes the on-going PV support measures. No new support policy measures were put in place in 2014.

Table 12 – Summary of PV support measures

Ongoing support measures	Comments
Feed-in tariffs for grid-connected applications (FIT < 100 kW and calls for tenders > 100 kW)	National policy
Off-grid applications: public FACE fund for rural electrification	National policy
Capital subsidies for equipment or total cost	Regional authorities through calls for proposals
Income tax credit	No longer available since 1 January 2014
Prosumers' incentives (self-consumption)	Regional authorities through calls for proposals
Commercial bank activities	Several types of offers

The French government's action plan for the development of renewable energy is that it should represent 23 % of energy consumption for 2020. In 2009, the Programming of investments (PPI) set a target volume of 5 400 MW for grid-connected PV applications to be reached by 2020.

In late 2010, the fast growing PV market prompted the Ministry of Ecology to pay specific attention to the financial impact of feed-in tariffs on the Contribution to Electricity Public Services (CSPE). In 2011, a ministerial order set up a new support mechanism for promoting photovoltaics, including two complementary incentives based on the power of installations:

- Feed-in tariffs adjustable each quarter for rooftop installations of PV power up to 100 kW;
- Calls for tenders for systems over 100 kW.

In early 2013, the Minister for Ecology introduced new measures to boost French PV activity. A volume of 800 MW a year was targeted for the next four years and equally split into two market segments: the first segment is divided between building-integrated systems (IAB) of up to 9 kW and simplified integration installations (ISB) up to 100 kW; the second segment of the annual target is allocated to calls for tenders as follows: 1/3 is targeted at ISB installations between 100 kW and 250 kW and the remaining 2/3 are targeted at installations over 250 kW.

3.1.1 Feed-in tariffs

EDF OA (EDF Agence obligation d'achat) and local distribution companies (ELD) are required to purchase PV electricity. Feed-in tariffs are set either by ministerial order or by calls for tenders.

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

Table 13 – Key dates of the feed-in tariff and income tax credit support policy

10 July 2006	Order introducing the attractive feed-in tariff (FiT) of 0,55 EUR/kWh for building-integration applications (following the 2002 FIT of 0,1525 EUR/kWh and the 2004 introduction of a 50 % tax credit for households).
10 Dec. 2010	Three-month suspension of the compulsory purchase scheme for installations exceeding 3 kW (the measure did not affect residential installations below 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 process for PV installations over 100 kW. Volume capped at 500 MW per year. Income tax credit decreased to 22 %.
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 from 1 Feb. 2013 to 10 March 2014). Volume capped at 800 MW per year until 2017. Income tax credit decreased to 11 %.
2014	Feed-in tariff bonus of 5 % or 10 % (see above) withdrawn 10 March 2014. Income tax credit phased out as of 1 January 2014.
2015	*Feed-in tariff T4 increased by 10 % (from April 2015).*

Table 14 – PV feed-in tariffs for the 4th quarter of 2014 (EUR/kWh)

Tariff category and PV system type	Power of PV installation (W)	Tariff Q4 2014 (EUR/kWh)	2014 Annual decrease (%) from Q1 to Q4	Decrease since March 2011 (%)
T1 - Building-integrated photovoltaic systems (IAB)	P ≤ 9 kW	0,2697	5,4 %	41,4 %
T4 - Simplified building-integrated systems (ISB)	P ≤ 36 kW 36 kW < P ≤ 100 kW	0,1374 0,1305	5,5 % 5,5 %	54,7 % 54,7 %
T5 - Other installations	0 <P < 12 MW	0,0680	7,6 %	43,3 %

NOTE 1 - In 2013, T2 and T3 tariffs were included in T1 and T4 categories. Technical and non-technical requirements for building integration and simplified building integration are detailed in the Order of 4 March 2011 (see 3.1.5).
NOTE 2 – For systems over 100 kW better tariffs can be obtained through successful participation in CRE's calls for tenders (see 3.1.2)

SOURCE: CRE, Ministry of Ecology, Sustainable development and Energy.

3.1.2 National calls for tenders

National calls for tenders for photovoltaic grid-connected installations with power over 100 kW were launched as early as 2011. Table 15 gives details of calls up to the beginning of 2015. The CRE, in charge of regulating the electricity and gas markets, manages all PV national calls for tenders. One of the selection criteria is the price that the bidder wishes to charge for the electricity supplied to the network over a period of 20 years.

3.1.2.1 Calls for tenders for 100 kW-250 kW systems

Calls for tenders, called 'simplified', refer to the implementation 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 (ISB). The first series of calls was launched in 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 totaling 156,9 MW, below the target volume previously set at 240 MW (Table 15).

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

A new 'Simplified' call for tenders (systems of 100 kW to 250 kW) for a volume of 120 MW with three bidding phases of 40 MW each was issued in March 2015.

3.1.2.2 Calls for tenders for systems over 250 kW

Calls for tenders, called 'ordinary', refer to the implementation 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), solar PV carports, concentrator photovoltaics (CPV) and solar thermal electric plants. 105 projects for a total of 520 MW were approved, 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 (140 MW), ground-mounted PV power plants with solar trackers (100 MW), concentrator power plants (concentration factor greater than 400, 20 MW), mixed installations concentrator/non-concentrator (40 MW + 40 MW) and PV carports (60 MW). 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 with 121 projects selected totalling 380 MW. The applicants' lowest electricity purchase price was for power plants with solar trackers and the highest for concentrator CPV plants.

To summarize, the two calls 'Simplified' and 'Ordinary' led to the selection of 1 569 PV installations with a total power of 1 178 MW and the weighted average of the electricity selling price of eligible projects ranged from 142 EUR per MWh to 230 EUR per MWh (Table 15).

Table 15 – Summary of CRE calls for tenders issued since 2011

	L: launch date DL: deadline	Total power target	Results (MW) E: eligible S: selected	Number of projects E: eligible S: selected	Electricity purchase price* (EUR/MWh)
1 - 'Simplified' calls: 100 kW - 250 kW Simplified building integration					
1.1 - First series of 7 phases (last 2 cancelled)**, August 2011**					
1st phase P1.1	L: 2011-08 DL: 2012-01	120 MW	S: 45,0 MW	S: 218	229* EUR/MWh
2nd phase P1.2	L: 2011-08 DL: 2012-03	30 MW	S: 20,9 MW	S: 109	211* EUR/MWh
3rd phase P1.3	L: 2011-08 DL: 2012-06	30 MW	S: 30,2 MW	S: 148	220* EUR/MWh
4th phase P1.4	L: 2011-08 DL: 2012-09	30 MW	S: 30,9 MW	S: 143	194* EUR/MWh
5th phase P1.5	L: 2011-08 DL: 2012-12	30 MW	S: 29,9 MW	S: 138	200* EUR/MWh
1.2 - Second series of 3 phases (replaces the 6th and 7th phases of the first series)**, March 2013**					
1st phase P2.1	L: 2013-03 DL: 2013-10	40 MW	S: 40,3 MW	S: 177	168* EUR/MWh
2nd phase P2.2	L: 2013-03 DL: 2014-02	40 MW	S: 40,7 MW	S: 193	165* EUR/MWh
3rd phase P2.3	L: 2013-03 DL: 2014-06	40 MW	S: 40,7 MW	S: 217	153 EUR/MWh
1.3 - Third series of 3 phases, March 2015					
3 phases	*L: 2015-03-17* *DL1: 2015-09-21* *DL2: 2016-01-21* *DL3: 2016-05-20*	*40 MW* *40 MW* *40 MW*	*n/a*	*n/a*	*n/a*
2 - 'Ordinary' calls: 250 kW - 12 MW Large roofs, ground-mounted plants, CPV, PV carports …					
CRE 1 > 250 kW	L: 2011-09 DL: 2012-02	450 MW	E: 1 891 MW S: 520 MW	E: 316 S: 105	213* EUR/MWh
CRE 2 > 250 kW	L: 2013-03 DL: 2013-09	400 MW	E: 1 726 MW S: 380 MW	E: 357 S: 121	142* EUR/MWh
CRE 3 > 250 kW	*L: 2014-11-26* *DL: 2015-06-01*	*400 MW*	*n/a*	*n/a*	*n/a*
Total (2011 - 2014) (excluding CRE 3, 400 MW and 3rd series 120 MW)		1 210 MW (excluding CRE 3, 400 MW and 3rd series 120 MW)	S: 1 178,6 MW	S: 1 569 syst.	

SOURCE: CRE (Energy Regulatory Commission).
*Weighted average calculated on eligible projects corresponding to different types of systems (Provisional value).

The third ordinary call for tenders CRE 3 > 250 kW was launched in November 2014 with a target of 400 MW, the bid submission deadline being set on 1 June 2015 (Table 16). The call specifications were previously reviewed and discussed by stakeholders. The call requires bidders to provide the electricity network manager with PV plant operating information, which is already applicable to installations of several MW. The expected electricity selling price should be within a range of 70 EUR/MWh–200 EUR/MWh, according to the types of applications.

Table 16 – New call for tenders (CRE 3) for systems over 250 kW (Nov. 2014)

Application	Installation power	Call target
Building with simplified integration criteria (ISB)	P ≤ 5 MW	100 MW
Building with superimposed modules on rooftop (BAPV)	P ≤ 5 MW	50 MW
Ground-mounted installations	P ≤ 5 MW	75 MW
	5 MW < P ≤ 12 MW	125 MW
PV carports for large car parks	P ≤ 4,5 MW	50 MW
Total		400 MW

NOTE - Deadline for submission: 1 June 2015. Definitions of ISB and BAPV are given in 3.1.5.

In May 2015, the Ministry of Ecology issued a new call for tenders for power plants with storage in non-interconnected insular territories (see 3.1.7).

3.1.3 Calls by regional authorities

France's regional and departmental authorities are carrying out photovoltaic promotion policies and a number of municipalities with diversified fields of action are also involved. The regions of Alsace, Aquitaine, Languedoc-Roussillon, Pays de la Loire and Poitou-Charentes have issued calls for proposals for photovoltaic self-consumption projects. They aim at supporting the setting up of PV installations without any specific requirements regarding building-integration, while showing a particular interest in the energy efficiency of buildings**.** The beneficiaries could 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.

3.1.4 Prosumers' development measures

PV projects under FIT contracts allow partial consumption of electricity production. There is no premium for self-consumption. As seen above, some Regions are promoting self-consumption projects through their calls for proposals.

A stakeholder consultation on self-consumption/self-production issues was hosted by the DGEC department of the Ministry of Ecology; one of the conclusions was that new support schemes and market segments should be defined at the end of an experimental period. A National call for self-consumption/production projects should be issued by mid-2015.

3.1.5 Building-integration development measures

Support measures through feed-in tariffs are geared towards building integration (BIPV is the general acronym). Two types of building integration, IAB and ISB, are taken into account in France:

- IAB - Total building integration: the photovoltaic array replaces the roof elements; it provides the main sealing of the building and should not exceed the roof plan by more than 2 cm. The building sealing is not provided by steel sheeting as in the case of ISB.
- ISB - Simplified building integration: the photovoltaic array replaces the roof elements and is mounted parallel to the roof plan.

Feed-in tariffs shown in Table 14 relate to IAB (tariff T1) and ISB (tariff T4) applications. The T5 feed-in tariff can apply to building-attached applications (BAPV). In building-attached

applications, photovoltaic modules (or arrays) are fastened onto the construction materials of a building and do not form part of the construction materials.

BAPV applications are mainly used in the overseas departments but their volume has remained marginal compared to building-integration applications in France. The new CRE 3 call for tenders issued in November 2014 identifies BAPV applications.

3.1.6 Rural electrification measures

Rural electrification mainly takes place in the French overseas departments. The operations are financed through FACE, a fund subsidizing rural electrification. Both FACE funding and an additional contribution of ADEME could eventually lead to 95 % coverage of residential PV investment costs.

In the overseas region of Guyane, six hybrid photovoltaic plants ranging from 50 kW to 150 kW were under construction in remote off-grid villages in 2014 and will be operational in late 2015.

3.1.7 Other measures including decentralized storage

The CRE 1 call for tenders launched in 2011 led to the selection of around 50 MW of power plants with storage designed for application in Corsica and the French overseas departments/regions. The storage batteries (Li-ion) contribute to the stability of the local power network by storing energy when surplus amounts are generated, and releasing it when needed.

Two power plants with storage were installed in 2014: a 5 MW plant with a storage capacity of 4,5 MWh in the region of Guyane and a 9 MW plant with 9 MWh storage in the region of La Réunion.

In May 2015, the Ministry of Ecology issued a new call for tenders to install 50 MW of photovoltaic plants (> 100 kW) with storage in non-interconnected insular territories (Corsica, Brittany islands and overseas departments). The target volume of this call is equally divided between installations on buildings and ground-mounted installations (submission deadline 20 November 2015).

3.1.8 Support measures phased out in 2014

Since 1 January 2014, private PV roof owners can no longer take advantage of the sustainable development CIDD tax credit (the measure was introduced in 2004). The revenue of PV electricity sales is not liable to Income Tax.

VAT for equipment and installation costs increased from 7 % to 10 % in 2014.

3.1.9 New support measures implemented in 2014

Feed-in-tariffs and calls for tenders are the two support measures currently in place. No new support measures were implemented in 2014 but in 2014/2015 some initiatives were announced such as the launch of new calls for tenders and the upgrading of T4 tariff.

3.1.10 Measures currently discussed but not implemented yet

The measures discussed in 2014 are to be defined with the final adoption of the new law on Energy Transition (feed-in tariffs, calls for tenders, self-consumption/production, target volumes and allocated budgets).

The ‘Energy Transition Law for Green Growth’ was voted on at first reading by the French National Assembly in October 2014. The law underlines the need for France to diversify its energy supply sources and sets the target of 32 % of renewables in final energy consumption for 2030.

Chapter 5 of the law is entitled 'Promoting renewable energy to diversify our sources of energy and enhance the resources of our territories'. It plans new support mechanisms for renewables, offering power producers the opportunity to sell electricity directly to the market while receiving a 'feed-in premium' that should replace guaranteed feed-in tariffs. In the case of photovoltaics, the support mechanism should only apply to large PV installations while feed-in tariff schemes should be maintained for smaller PV systems. The involvement of local authorities and private individuals in renewable energy projects should be encouraged. At the time of writing this report, final approval was still pending and elements of the new pricing mechanisms, target volumes of the PPE (multi-annual programming of energy) and budgets had not been published.

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 2014, the CSPE amounted to about 2 200 MEUR (source CRE).

The CSPE is a fee paid by electricity customers according to the amount of electricity they consume. In 2014 the charge stood at 16,50 EUR/MWh. The role of CSPE is to balance the additional costs borne by electricity operators for their public service mission, as for instance, the additional costs incurred to ensure equal electricity rates for all French citizens (including overseas departments), specific pricing for people facing financial difficulties, and also the costs resulting from support measures for renewable energies and cogeneration.

3.2 Indirect policy issues

As mentioned below, various indirect initiatives have had a favourable impact on the development and the implementation of PV power applications in France.

3.2.1 International policies affecting the use of PV power systems

The organizations IEC, CENELEC and IEA participate in the promotion and development of photovoltaics. ADEME has contributed to the setting up of the TC 82 Technical Committee of the IEC and the PVPS Implementing Agreement of the IEA. French experts participate in most of the current cost-shared studies within the various Tasks of IEA PVPS (Tasks 1, 8, 9, 12, 13 and the new Task 15). Specialist contributions to the IEC/TC 82 and CENELEC/TC 82 are coordinated through the National UF 82/AFNOR Committee.

Additionally, International bilateral cooperation promotes knowledge and experience sharing as in the case of the Franco-German Renewable Energies Office *(Office franco-allemand pour les énergies renouvelables*).

The European Commission plays an important role in the promotion of PV through its energy Directives, R&D programmes (Horizon 2020) and financing tools (FEDER fund, BEI, etc.).

3.2.2 Introduction of favourable environmental regulations

Thermal regulation 'RT 2012' sets the maximum primary energy consumption level for new buildings at 50 kWh/m² per year. It offers new opportunities for the development of the solar market in France; 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

Operators such as Bpifrance, Business France (formerly Ubifrance), Coface (export credit insurance), Bpifrance Export and the Ministry of the Economy through their financial aid tools, provide assistance to French companies in developing abroad. The exhibition ERA 2014 on renewables, clean energies and sustainable development was held in Algeria, 27-

29 October 2014. A French pavilion under the auspices of Business France, IMEDER, SER and ADEME hosted the French companies wishing to present their products and expertise. Under the label of 'France Solar Industry', several French PV companies have recently taken part of an official French presidential trip for the signing of a contract with the Government of the Philippines to install 30 MW of PV systems.

The label 'France Solar Industry' –a trademark of the Syndicat des énergies renouvelables SER– brings together about 30 companies active in the PV, CPV and solar thermal electric sectors. Its objective is to provide the French industry and more particularly SME-SMIs with some promotional support on the international market.

The Mediterranean Institute of Renewable Energy (IMEDER) is a group of professional organizations on both sides of the Mediterranean setting up a variety of conferences and exhibitions, for instance the Euro-Mediterranean meeting held in Perpignan on 8 July 2014, within the framework of the 8th International DERBI/JNES Conference.

France along with three North-African countries has created a website called So-med to exchange information and expertise on solar energy and its applications. This initiative funded by the French Investments for the Future programme originates from INES2 (one of the Institutes for Energy Transition).

4 R&D AND BUDGETS

4.1 Highlights of R&D

The French policy of research and innovation is implemented through agencies under the government's supervision, such as ADEME (French Environment and Energy Management Agency), ANR (French National Research Agency) and Bpifrance (organization providing support to SME-SMIs for their innovation projects). Research activities range from upstream studies (ANR's programme) to finalized projects (AMI PV programme from ADEME) and industrial prototypes (re-industrialization support programme of Bpifrance). These R&D projects are part of a government initiative called Investments for the Future (Investissements d'avenir). About 40 research teams and practically all manufacturers of PV materials and PV components are involved in R&D programmes under private–public partnerships.

Research and technological development (RTD) activities cover the full spectrum of topics in line with the Solar Europe Industry Initiative: performance enhancement, energy cost reduction, quality assurance, long term reliability and electricity network integration. ADEME manages nine projects of the 'AMI PV' RTD programme which should be assessed from 2015 to 2017.

In 2013/2014, ADEME launched two calls for proposals on the following topics: 'Optimized Integration of Renewable Energies, Intopenr' and 'Sustainable energy'. Three PV projects relating to the development of a hybrid PV-T process, the characterization of PID defects and the failure analysis of PV modules were selected.

During 2014, the French National Research Agency (ANR) was in the process of assessing seventeen photovoltaic research projects selected under the 'PROGELEC 2011-2013' programme (Renewable electricity production and management). At the end of 2013, ANR launched a generic call for proposals with a wide range of scientific topics. Photovoltaics was included in the research theme called 'Secure, clean and efficient energy'. Four basic PV research projects were approved on the following topics: dipolar dyes for OPV cells, metal-organic chromophores for hybrid cells, crystallization of seeded silicon and tandem radial junction Si nanowires/a-Si/µc-Si cells.

The 17th and 18th calls for proposals of the French Single Interministerial Fund (FUI) led to the selection of three new projects. The selected topics related to the improvement of PV-T hybrid modules, the development of a printing process for PV cells and the project of associating agricultural activity with a PV plant equipped with solar trackers.

INES, the National Solar Energy Institute, is the main organization in charge of RTD 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 building applications.

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 began in 2014.

Other public laboratories from the CNRS (National Scientific Research Council), the CEA, universities and engineering schools contribute to RTD programmes.

The European Horizon 2020 Research and Innovation programme allows French private and public research teams to collaborate with their European colleagues. Another opportunity for cooperation is through the network of European national and regional funding agencies called Solar-ERA-net. Their financial resources are pooled in a coordinated way to support

targeted European transnational private-public projects. Their second joint call for proposals covered eleven PV and CSP topics.

The PV research community attended the 4th PV National days (JNPV) organized near Paris by the CNRS and the Federation of PV research labs (FedPV) from 2 to 5 December 2014.

4.2 Public budgets for R&D

RTD projects receive funding through national public agencies such as ADEME, ANR and Bpifrance which is in charge of the Single Interministerial Fund (FUI). To respond to the FUI calls for proposals, the submitted projects must be backed by Competitiveness clusters such as Tenerrdis or Derbi. Regional councils can also provide financial support to collaborative projects. Projects are funded through subsidies and/or repayable advances.

Public research organizations such as the CNRS, CEA and universities contribute financially to research projects through staff salaries and annual allocations for the operation of laboratories. They are not included in the intervention budget (Table 17).

The budget for market stimulation through feed-in tariffs is described in section 3.1.11.

Table 17 – Public budgets for R&D 2014 (10^6 EUR)

Public organization	Budget
Intervention budget of National Agencies: ADEME, ANR, Bpifrance (FUI). Not including Investments for the Future programme 2014 (*programme Investissements d'avenir*).	7 MEUR
Regional councils budget (contribute to FUI calls for proposals)	n/a

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 feedstock, ingots and wafers (crystalline silicon)

There is no industrial production of silicon feedstock in France but two companies are working on the whole manufacturing process of photovoltaic solar grade silicon through metallurgical methods (as opposed to the traditional chemical method):

- Ferropem/FerroAtlántica, Apollon Solar, INES and SIMAP/CNRS are collaborating on the development of a pilot production of 300 t/year (Photosil project). 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 (AMI project of ADEME).
- EMIX Company, a subsidiary of FerroAtlántica, specialized in electromagnetic cold crucible casting, participates in a Spanish project on solar PV metallurgical grade silicon.

The multicrystalline silicon sector (large-grain crystalline material) has historically been favoured by the French public authorities from the 1980s.

Photowatt/EDF ENR PWT, founded in 1979 and owned by EDF ENR since March 2012, is France's long-standing vertically integrated manufacturer of crystalline silicon materials. Multicrystalline silicon ingots are obtained by directional solidification. The annual production capacity is equivalent to 100 MW. The technique of using wire saws for slicing silicon ingots into thin wafers was pioneered by Photowatt in partnership with a Swiss company. This technique is now largely used in industry. The annual slicing capacity is equivalent to 100 MW. The company also manufactures cells and modules (see below).

ECM Technologies develops and markets multicrystalline and quasi-monocrystalline silicon ingot crystallization furnaces. The ingots can reach up to 800 kg.

An alternative approach to making silicon wafers without slicing ingots is proposed by S'Tile which is developing a 15 MW pilot line to manufacture silicon wafers by sintering metallurgical grade silicon powder. Cells are elaborated on these wafers through technologies developed by partner companies.

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 sliced with wire-saw	100 MW equivalent

5.2 Production of photovoltaic cells and modules

PV cell and module manufacturers and their production capacity are listed in Table 19.

Table 19 – Cell and module production capacity 2014

Cell/Module manufacturer	Technology	Production capacity (MW/y)	
		Cell	Module
Wafer-based PV manufactures			
Cell manufacturers: - Photowatt/EDF ENR PWT	mc-Si, qc-Si	100	(see below)
- Irysolar (foundry services)	sc-Si	10	-
Module manufacturers: - Elifrance - Fonroche Énergie - Francewatts - Photowatt/EDF ENR PWT* - Sillia VL - SCNAsolar - Systovi - Sunpower/Total Group - VMH Énergies - Voltec Solar	sc-Si, mc-Si, qc-Si	-	670
Total		**110 MW**	**670 MW**
Thin film manufacturers			
- Nexcis (pilot production)	CIGS Electrodeposition	-	-
- Solems small-energy applications	a-Si:H PECVD	-	-
Concentrator PV			
Cells: - Soitec SA (R&D)	III-V compounds Multijunction	-	-
Modules: - Heliotrop (pilot line)	Fresnel lens, 1024 suns	-	-

SOURCE: SER, ADEME. *In 2014, Photowatt manufactured its modules both in France and abroad.

5.2.1 Crystalline silicon PV cells

Photowatt/EDF ENR PWT, as mentioned above, is a vertically integrated manufacturer of crystalline silicon materials. PV cells are prepared from thin wafers sliced from silicon ingots. The cell production capacity of the company is 100 MW per year. Photowatt participates in a number of collaborative R&D projects on crystalline silicon.

Irysolar, a subsidiary of OEM Semco Engineering, operates a production line for the manufacturing of p-type silicon cells (foundry services, custom-made cells, etc.) and is involved in an R&D project on n-type cells. Annual production capacity is 10 MW.

5.2.2 Concentrator photovoltaic cells

Soitec SA develops multijunction photovoltaic cells GaInP/GaInAs/Ge with proprietary technologies from microelectronics. In December 2014, in collaboration with the Fraunhofer Institute ISE and CEA-LETI, a quadruple junction cell reached a record conversion efficiency of 46 % (concentration factor of 500). Their common aim is to reach 50 % efficiency. The concentrator photovoltaic cells are placed at the focal point of a light concentrator (see concentrator module).

5.2.3 Photovoltaic modules

Table 19 lists the PV module manufacturers operating in 2014 with a production facility located in France.

5.2.3.1 Crystalline silicon PV modules

Ten manufacturers in France produce flat plate modules through cell encapsulation. Their annual module production capacity is around 670 MW. Photowatt/EDF ENR PWT used to manufacture its modules from its own cells, but since 2011 this activity has been outsourced

to foreign subcontractors. In 2014, the company restarted its module activity in France. Whatever their manufacturing origin, the modules retain their Photowatt brand name.

Sunpower (Total Group subsidiary) manufactures PV modules in Toulouse. A smaller factory in Porcelette produces modules from PV laminates. There are two other module factories in the Philippines and Mexico. The modules use single-crystal silicon back-contact cells manufactured by Sunpower in Malaysia and the Philippines. The conversion efficiency of the modules exceeds 21 %, one of the highest on the market.

Between 2008 and 2010, a few SME companies started manufacturing photovoltaic modules based on imported crystalline silicon cells, but some of them ceased activity after two or three years of production. In 2014, Sillia Energie (Sillia VL) in partnership with Urbasolar took over the crystalline silicon module production of Bosch Solar France.

Overall, French companies manufacture a wide range of photovoltaic products from standard modules to modules specifically adapted to building-integration and architectural elements. Some other companies, Luxol and Captelia, manufacture PV tiles 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 sulphur and selenium atmosphere. Research on this process was initially conducted by the IRDEP joint research Institute (EDF and CNRS).

In the field of photovoltaic organic materials (OPV), two companies Armor and DisaSolar use printing techniques. The entry of OPV materials onto the electric energy market still requires further development.

5.2.3.3 Concentrator modules

Concentrator photovoltaics (CPV) was one of the PV applications retained by CRE’s calls for tenders.

Heliotrop is developing photovoltaic modules of the third generation with a high concentration factor (1024 suns with Fresnel lens). An industrial manufacturing line is under development. Their CPV modules refer to International Standard IEC 62108. A significant part of CPV projects selected by CRE’s calls involve Heliotrop's concentrator modules.

Soitec operates a CPV module production line in San Diego (US). At the end of 2014, the company was restructuring its industrial development and looking for a buyer. Nevertheless, Soitec will still provide CPV modules for the power plants that were selected in CRE 1 call for tenders. With its partners, Soitec continues the development of very high efficiency multi-junction cell (see CPV cells).

5.2.4 Solar trackers

Exosun and Optimum Tracker are active in supplying solar tracking technologies (single-axis and dual axis) for utility scale PV plants. The companies participate in several projects selected by CRE’s 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 in August 2014, PV waste management has become a legally-binding requirement for any France-based PV module importer or manufacturer. PV CYCLE France SAS was founded in February 2014 by several PV players to offer waste management solutions to the French industry. With more than 10 000 tonnes of treated PV modules and a comprehensive collection network, PV CYCLE is the only PV-focused scheme in Europe to operate on an industrial scale.

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 ranges of inverters. Many of these companies are active 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 may apply for technical assessment certificates such as ATec PV/CSTB, Pass'Innovation Vert/CSTB or an ETN certificate (assessment of a new technique).

Solar PV carports for large car parks is 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 the BIPS study carried out for ADEME (unpublished to date), the total number of full-time equivalent (FTE) jobs in component manufacturing, engineering studies, installation, and maintenance, was estimated at 8 500 in 2014 (Table 20).
The fluctuation in employment is directly related to the activity in the installation, connection and maintenance sectors which are the main sources of PV jobs.

In 2014, a new calculation method was introduced to assess the number of jobs not only direct (8 500), but also indirect (5 000) and induced jobs (3 000). A downward trend has been observed since 2010/2011, even if comparison with previous years cannot be a straightforward exercise owing to the change in calculation methods.

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

Table 20 – Estimated PV-related labour places in 2014 (FTE)

Segment	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.	8 500

SOURCE: ADEME-BIPS (provisional). CNRS/Cellule Energie

6.2 Business value

Global investments in PV installations were estimated at 1,5 billion euro in 2014 (source: ADEME-BIPS).

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. Public authorities, France's Competition Authority and France's Energy Regulatory Commission (CRE), supervise the application of the new market regulations.

The electricity distribution networks belong to local authorities (French municipalities or groups of municipalities), who subcontract the management and operation to ERDF (95 % of continental France network) or to local distribution companies (ELD, 5 %) through public service delegation. ERDF, a subsidiary of EDF, is a distribution network operator created on 1 January 2008. RTE (*Réseau de Transport d'Électricité*) which is also a subsidiary of EDF, is responsible for the high voltage HVB transmission of electricity.

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

7.2 Interest from electricity utility businesses

The two major energy companies EDF and GDF SUEZ 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. In parallel, electric power distribution companies and electricity transmission companies are experimenting on new solutions to integrate renewables into the network. For example, the 'Nice Grid smart solar district project' located in the municipality of Carros near Nice, brings together a broad range of stakeholders. The project aims to develop a smart electricity grid integrating photovoltaics, energy storage Li batteries and smart power meters installed in the homes of volunteer participants. Nice Grid intends to turn passive consumers into active 'prosumers' (producer-consumers). The project under completion receives funding from the Investments for the Future programme.

7.2.1 EDF Group

EDF EN (EDF Énergies Nouvelles) created in 1990, is a subsidiary of the French utility EDF. EDF EN develops, builds and operates renewable energy plants in Europe and North America (total 7,5 GW). By the end of 2014, the company had installed 430 MW of photovoltaic plants in France. 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 and was 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 systems for all types of roofs including individual housing, agricultural, industrial and administrative buildings, together with supervision and maintenance (around 14 000 installations).

- EDF ENR PWT (Photowatt) manufactures crystalline silicon ingots, wafers, cells and PV modules (see 5.1 and 5.2).

7.2.2 GDF SUEZ Group

GDF SUEZ (new name: Engie) operates as systems integrator and as main contractor of turnkey projects for private and institutional investors. With its subsidiaries

La Compagnie du Vent, La Compagnie Nationale du Rhône and Ineo, GDF SUEZ claims an operational capacity of 105 MW in France, with the goal of reaching 200 MW by 2016.

7.2.3 Other companies and RE producers

The 3rd largest electricity producer E.ON France operates two PV plants totaling 10,5 MW including an 8 MW PV plant.

In addition to 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. Their projects can be either call winners or beneficiaries of over-the-counter (OTC) purchase contracts. In this respect, the introduction of the Ester project is the result of an alliance between the Poitou-Charentes regional council, Solairedirect SA and the electricity supplier Séolis.

7.3 Interest from local authorities

In 2012/2013, the regional authorities drew up some provisional programmes on climate, air and energy (SRCAE), planning around 15 GW of PV installations for 2020. The regional schemes relating to renewable energy grid-connection (S3REnR) which have already been started in 11 different regions, aim at adapting and improving the electricity network. Each producer with an installation of over 36 kVA will have to contribute financially for grid connection and its strengthening.

France's regional and departmental authorities in partnership with ADEME have focused their support policies on the development of self-consumption projects and collaborative citizens' initiatives. In 2014, some regions such as Alsace, Aquitaine, Languedoc-Roussillon, Pays de la Loire and Poitou-Charentes launched calls for tenders with a variety of objectives. One of the calls, for instance, planned to allocate a capped investment subsidy to systems below 250 kW, provided that 50 % of the PV production was self-consumed.

A number of municipalities with diversified fields of action are also involved. Enerplan professional union maintains a comprehensive list of local authorities' support measures.

8 STANDARDS AND CODES

8.1 Standards

Since the merger of AFNOR and UTE (electrotechnical field) in 2014, AFNOR has been the sole member to represent 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 PV component standards but refers to IEC and CENELEC Standards. The French National PV standardization committee AFNOR/UF 82 with its 29 experts participates in the vote of acceptance of IEC and CENELEC Standards after comments and amendments. At the request of these organizations, International Standards are translated into French through AFNOR. They are incorporated into the French Standard NF 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.

8.2 Technical guides

Some significant technical documents have recently been updated: 'Photovoltaic systems without storage and connected to the public distribution network' (AFNOR UTE C 15-712-1) and 'Stand-alone photovoltaic systems not connected to the public grid and with battery storage' (AFNOR UTE C 15-712-2). The document 'Managing risk in photovoltaic installations' gives advice to firefighters working on premises with PV modules (GIMELEC/SER/ADEME). In early 2014, EDF OA published a brochure entitled 'What should I do in case of destruction or dismantling of my installation?' This document is intended for photovoltaic electricity producers who have experienced damage or want to dismantle their PV arrays.

The PV branch of the French Building Federation has published a number of technical guides such as 'Drafting contractual documents', 'Performance and energy consumption' and 'Rules of conduct of PV in the building sector'. The Construction Quality Agency (AQC) has updated its technical datasheets on sealing issues.

Other user guides have been re-edited: 'Guide for connecting a PV installation up to 36 kVA' (ERDF); 'Administrative, budget and tax management for inter-municipal PV projects' (CRER Poitou-Charentes).

ADEME has published a comprehensive guide 'Photovoltaics and territorial collectivities (Oct. 2014). It provides local authorities with information and guidance on financing options and investments in photovoltaics, and also gives a number of examples of current achievements.

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 annually undergo a quality audit on their design and manufacture.

Certisolis now carries out quality controls of PV modules following reception on the installation site. This process is currently underway at Europe's largest 300 MW power plant now under construction in the region of Aquitaine.

In 2008, the CSTB (Scientific and Technical Centre for Construction) set up a technical assessment procedure to ensure that photovoltaic products and processes used on a building would pose minimal accident risk and would be covered by basic insurance contracts. Photovoltaic Technical assessments (Atec PV) are renewable, modifiable and readily available. They 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. At the end of 2014, approximately 30 ATec PV and 13 Pass'Innovation Vert were still valid.

To meet insurance requirements, some products and processes used in the PV building sector can also be evaluated through an Assessment of new technique (ETN). An ETN (*Enquête de Technique Nouvelle*) is issued by a registered inspector relying on 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*). From 1 July 2014, homeowners wishing to benefit from a public subsidy have had to call on qualified professionals who carry the RGE quality label and comply 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

During 2014, 939 MW were grid-connected in France. The 44 % growth on the previous year was mainly due to CRE's calls above 250 kW. The French total photovoltaic capacity reached 5 648 MW with 346 950 installations, thus slightly exceeding the target of 5,4 GW initially set for 2020.

The industry remains fragile despite the 2014 rebound. Module manufacturers are working below their production capacity. Small rooftop installers are losing business and yet some larger groups and independent operators have managed to maintain their activity by responding to national/regional calls for tenders and developing projects abroad.

R&D remains active. The agencies ADEME, ANR and Bpifrance have granted funds to private-public studies on the insertion of PV into the network and the development of new processes, devices and materials.

The French photovoltaic sector development is mainly driven by the National policy of feed-in tariffs and calls for tenders.

Calls for tenders for systems above 100 kW have gained in popularity. Since the first round of calls was launched in 2011, 1 610 MW of projects have been approved by the Ministry, among which 500 MW in 2014.

Several initiatives were introduced by the Ministry of Ecology in 2014. Two new calls for tenders were issued for systems above 100 kW and above 250 kW with a total target volume of 520 MW. In early 2015, the ministry announced a 10 % increase of the T4 feed-in tariff for simplified building-integration applications and the launch of a call relating to projects with storage in non-interconnected insular territories. A call for self-consumption projects was also under consideration.

In parallel with National support policies, a number of Regional support measures have also been implemented towards renewables as factors of local development. For instance, five regional councils have issued calls for proposals on self-consumption projects.

Another 2014 event was the vote at first reading of the 'Energy Transition Law for Green Growth'. The draft was voted on by the French National Assembly in October 2014. At the time of writing this report, final approval by Parliament was still pending and details of new support mechanisms, target volumes and public budgets had not been officially announced.

As regards short and medium term objectives, the Regions have planned a total volume of around 15 GW by 2020, the industry maintains its objective of 20 GW and ADEME is considering a potential of 33 MW for 2030.

France will be the host country for the U.N. Climate Change Conference (COP 21) in December 2015. This conference should lead to a universal binding agreement on climate, thus encouraging a global transition towards low-carbon societies. All PV stakeholders are ready to welcome new opportunities under such favourable conditions.

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ANNEX A DEFINITIONS, SYMBOLS AND ABBREVIATIONS

For the purposes of this IEA PVPS National Survey Report, the following definitions, symbols and abbreviations apply:

BAPV: building-attached photovoltaic(s). [adj. or noun]

BIPV: building-integrated photovoltaic(s). [adj. or noun]

FIT: feed-in tariff.

IAB: (total) building integration.

ISB: see simplified building integration.

PV: photovoltaics (noun) or photovoltaic (adj.).

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):

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.

Final annual yield: total PV energy delivered to the load during the year per kW of power installed.

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

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

Hybrid system: a system combining PV generation with another generation source, such as diesel, hydro, wind.

Installed PV power: power delivered by a PV module or a PV array under Standard test conditions (STC) – irradiance of 1 000 W/m^2, cell junction temperature of 25^{o}C, AM 1,5 solar spectrum.

Module manufacturer: an organization carrying out the encapsulation of PV cells in the process of the production of PV modules.

Off-grid domestic PV power system: system installed to provide power mainly to a household or village not connected to the (main) utility grid(s). A means to store electricity is used (most commonly lead-acid batteries). Also referred to as 'stand-alone PV power system'. Can also provide power to domestic and community users (plus some other applications), often as a hybrid with another source of power.

Off-grid non-domestic PV power system: system used for a variety of industrial and agricultural applications such as water pumping, remote communications, telecommunication relays, safety and protection devices, etc. that are not connected to the utility grid. A means to store electricity is used. Also referred to as 'stand-alone PV power system'.

PV support measures (the following definitions apply to all IEA PVPS National Survey Reports):

Feed-in tariff	an explicit monetary reward is provided for producing PV electricity; paid (usually by the electricity utility business) at a rate per kWh that may be higher or lower than the retail electricity rates being paid by the customer
Capital subsidies	direct financial subsidies aimed at tackling the up-front cost barrier, either

	for specific equipment or total installed PV system cost
Green electricity schemes	allows customers to purchase green electricity based on renewable energy from the electricity utility business, usually at a premium price
PV-specific green electricity schemes	allows customers to purchase green electricity based on PV electricity from the electricity utility business, usually at a premium price
Investment funds for PV	share offerings in private PV investment funds plus other schemes that focus on wealth creation and business success using PV as a vehicle to achieve these ends
Income tax credits	allows some or all expenses associated with PV installation to be deducted from taxable income streams

PV system: set of interconnected elements such as PV modules, inverters that convert d.c. current of the modules into a.c. current, storage batteries and all installation and control components with a PV power capacity of 40 W or more.

Rated power: amount of power produced by a PV module under Standard test conditions (STC), written as W (watt).

Turnkey price: price of an installed PV system excluding VAT/TVA/sales taxes, operation and maintenance costs but including installation costs. For an off-grid PV system, the prices associated with storage battery maintenance/replacement are excluded.

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

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