

National Survey Report of PV Power Applications in FRANCE 2013



PVPS

PHOTOVOLTAIC
POWER SYSTEMS
PROGRAMME

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FOREWORD

This report prepared by ADEME/SRER is part of a collaborative research project within the international IEA PVPS programme of cooperation.

The French Agency for Environment and Energy management (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 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 Cooperation and Development (OECD) which carries out a comprehensive programme of energy cooperation among its 29 member countries. The European Commission also participates in the work of the Agency.

The IEA Photovoltaic Power Systems Programme (IEA PVPS) is one of the 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 24 participating countries are Australia, Austria, Belgium, Canada, China, Denmark, France, Germany, Israel, Italy, Japan, Korea, Malaysia, Mexico, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Thailand, Turkey, the United Kingdom and the United States of America. The European Commission, the European Photovoltaic Industry Association, the US Solar Electric Power Association, the US Solar Energy Industries Association and the Copper Alliance are also members.

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 www.iea-pvps.org

INTRODUCTION

This document is the French National Survey Report on photovoltaics for the year 2013. It has been prepared by ADEME as part of an international study commissioned by working group 1 (*Task 1*) of the IEA Photovoltaic Power System Programme (IEA PVPS). Each participating country in the PVPS programme produces its own national survey report (NSR) along common guidelines.

Information from this document and from other national survey reports will be used as input to the annual synthesis report 'Trends in photovoltaic applications', available on the website www.iea-pvps.org.

This report provides a comprehensive review of photovoltaic activities in France in 2013. It describes the current state of the PV market, including French authorities' support measures and economic aspects. It gives an account of PV industry with key manufacturers and operators as well as R&D programmes. The data contained in the report concern the year 2013.

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 Syndicat des énergies renouvelables (SER) and by ENERPLAN union, publications Systèmes solaires, reports by Observatoire des énergies renouvelables (Observer), Plein Soleil magazine, websites (institutional, photovoltaic.info, L'écho du solaire, etc.), 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° 498, February 2014, n° 522, May 2014.
- - *Panorama des énergies renouvelables 2013*, RTE, SER, ERDF, ADEeF, January 2014.
- - *Atlas 2013 des grandes centrales PV > 1 MW*, Observer, hors-série n° 10, November 2013.
- - *Cartographie régionale des centrales photovoltaïques de 100 kW à 999 kW en 2013*, Le Journal des énergies renouvelables, n° 218, November 2013.
- - *Marchés, emplois et enjeux énergétiques des activités liées aux énergies renouvelables*, ADEME (produced by In Numeri), draft version, May 2014.
- - *Bilan électrique*, (RTE Electricity Report 2013), RTE, January 2014.
- - *Annuaire du Syndicat des énergies renouvelables 2013*, SER, January 2014.
- - *Coûts et rentabilité des énergies renouvelables en France métropolitaine*, CRE, April 2014.

EXECUTIVE SUMMARY

The report prepared by ADEME is part of a collaborative research project within the IEA PVPS programme of cooperation. It provides a comprehensive review of photovoltaic activities in France in 2013.

Installed photovoltaic power

A total of 643 MW of grid-connected photovoltaic systems were installed in France in 2013. This compares to 1 115 MW in 2012 and to the record high of 1 770 MW in 2011. In 2013, grid-connected distributed photovoltaic systems, mainly building integrated, amounted to 61 % of total installed capacity and ground-based centralized PV plants to 39 %. The photovoltaic power capacity installed in 2013 reached 51 % of the new electrical capacities commissioned in Metropolitan France. The volume of the off-grid stand-alone photovoltaic system sector remained low with 0,1 MW installed.

By the end of 2013 the cumulative power capacity of all grid-connected photovoltaic systems in operation in France was 4 703 MW with 318 924 systems, a 16 % increase against 2012. Cumulative PV capacity represented 3,4 % of national electricity generation capacity. Annual photovoltaic energy production was estimated at 4,6 TWh and covered 1 % of total national electric energy consumption.

Building integrated systems with a power up to 3 kW reached 83 % of all installations and 15 % of total power capacity while systems exceeding 250 kW accounted for 0,3 % of all installations and 44 % of total power capacity. In four regions of the south of France the cumulative volume exceeded 400 MW per region. PV shelters for car parks and ground-mounted power plants with solar trackers increased market share.

Support measures

In 2013, guaranteed feed-in tariffs and tax credit for private individuals were the French government's main support measures. Feed-in tariffs aim to promote building integrated photovoltaic systems. The tariffs are revised each quarter and guaranteed for a period of 20 years. In early 2013, the pricing schedule was simplified (three tariff categories instead of five). In addition, a tariff bonus of either 5 % or 10 % was applied if the photovoltaic modules installed were manufactured in the European Economic Area. This bonus was granted between 1 February 2013 and 10 March 2014 and the tax credit incentive was suppressed by the end of 2013.

For building-integrated systems up to 9 kW the tariff decreased by 7,9 % over the year to reach 0,2910 EUR/kWh in the fourth quarter. Tariffs for simplified building-integrated systems (ISB) up to 100 kW, reached the maximum 20 % reduction level during the year to stand at around 0,14 EUR/kWh. For all other systems, the guaranteed tariff at the end of 2013 was 0,0755 EUR/kWh. The projects selected through CRE's calls for tenders resulted in purchase tariff offers ranging from 0,10 EUR/kWh to 0,20 EUR/kWh.

In 2013, the Ministry of Ecology announced that the targeted annual volume of installations would be set at 800 MW, equally divided between systems installed on buildings with power up to 100 kW (regulated tariff) and systems with power over 100 kW, through a series of calls for tenders. In that case, electricity purchase tariff is set by the project bidders themselves.

The cost of these purchase tariff measures is borne by electricity consumers via the CSPE fee (Contribution to Electricity Public Services).

At the beginning of 2013, the French Energy Regulatory Authority (CRE) issued new calls for tenders. The first for building integrated systems ranging from 100 kW to 250 kW and a target volume of 120 MW equally split into three periods of 40 MW. The second call for systems with a power over 250 kW and a target volume of 400 MW. A new call for tenders in this category is planned for 2014 after ministerial consultation with industry on the call's

terms and conditions. The calls for tenders launched in 2011, 2012 and 2013, met growing interest with a total of 4 GW of projects received by the CRE. However, the Ministry accepted a volume of 1,1 GW so as not to exceed the target volume previously fixed.

Research and Development

Most R&D projects and industrial developments are funded by three national public organizations: ADEME, ANR and Bpifrance. These organizations, under the control of their ministries, manage the national 'Investment for the future' programmes and calls for expression of interest (AMI). ADEME is in charge of the 'AMI PV' programme with nine projects to be assessed in 2015. In 2013, ADEME issued a call for R&D projects on the subject of 'Optimized integration of renewables and demand-side management'. In early 2014, two new AMI programmes were issued: the first AMI covering photovoltaic processes and systems, and the second dealing with smart electrical systems, including the theme of integration of renewable energy generation. ANR is conducting the Progelec programme with seven new research projects selected in 2013 which brings the number of PV studies under way up to 17.

INES and IPVF research institutes are strengthening cooperation with industry on a variety of projects.

Price of photovoltaic systems

The significant fall in system prices recorded in recent years has boosted the development of medium and high power systems. Prices started levelling off in 2013.

For residential building-integrated systems (IAB), the average turnkey price was about 3,6 EUR/W in 2013. The price for simplified building-integrated systems (ISB) on commercial and industrial buildings came to around 1,9 EUR/W and to 1,5 EUR/W for high-power grid-connected ground-mounted systems (excluding VAT).

Photovoltaic industry

The French photovoltaic component industry has had some difficulty in facing stiff international competition and adapting to the government's revisions of support measures. Nevertheless, an active network of developers and independent entrepreneurs has taken advantage of calls for tenders to develop their activity both in France and on the international market.

French PV component production capacity remains modest compared to the leading countries of the sector. Twelve companies manufacture PV modules with an annual production capacity of 600 MW. A vertically integrated industrialist manufactures multicrystalline silicon ingots, thin wire-sawed wafers (annual capacity 80 MW) and PV cells. Two other companies also manufacture crystalline silicon cells, bringing national annual cell production capacity to approximately 135 MW. Two industrial development initiatives can be noted in the concentrator photovoltaic sector (cells and modules) and in solar trackers for ground-based power plants.

In 2013, employment directly linked to the PV sector was estimated at around 10 130 full-time equivalent jobs, down by 40 % from the previous year.

Prospects

The 2009 government development plan aimed at installing 5,4 GW by 2020 within a well-defined framework of tax and tariff measures. This objective will be achieved sooner than expected. Professional unions are pushing for a better visibility and simplification of government action and measures in particular for SME-SMIs. The law on energy transition to be voted in 2014 will determine the government's policy on renewables.

It is generally acknowledged that the objective of installing 20 GW should be achieved by 2020.

1 PHOTOVOLTAIC INSTALLATIONS

1.1 Photovoltaic system applications in France

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, farms, telecommunication repeaters, water pumping systems, etc.) and more recently as decentralized power plants supplying electricity to the public electricity network.

Photovoltaic systems consist of both electrical and electro-technical components: the photovoltaic modules exposed to sunlight are the heart of the electric energy generator (the modules are arranged into panels, strings and arrays). The direct current produced by these modules is converted via an inverter into alternating current, at the required rating. Electrochemical batteries may store the electric energy when necessary, generally for electrification of isolated sites. PV systems also feature other equipment together with control and safety devices.

The technical data of interest are power of systems (W, kW, MW...), delivered energy (kWh, MWh, TWh), and final yield (kWh/kW). 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 (kW) produces around one thousand kilowatt-hours of energy over a year. The owner of a grid-connected PV system invests in a certain amount of power (EUR/W) and sells the energy produced (EUR/kWh).

NOTE – The power of a PV module is measured in the manufacturing plant under standard test conditions (STC). The photovoltaic power data published in this report are expressed in watt (W) and its multiples kW, MW and GW. Some professionals use the non-standardized unit peak-watt (Wp).

1.1.1 Categories of systems analysed

In line with the IEA's statistics requirements the report considers three types of photovoltaic systems:

- **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 from 1 kW to 1 MW).

NOTE – The sale of electricity generally provides a secondary income source for the owner of the system.

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

NOTE – The sale of electricity generally provides a primary income source for the owner of the system.

- **Off-grid PV power system:** system installed to provide power mainly to rural isolated homes (off-grid domestic) or for technical applications such as telecommunication repeaters, water pumping systems, etc. (off-grid non-domestic). Power range: 1 kW to several 100 kW.

NOTE 1 – A stand-alone PV power system includes a storage battery and, in some cases, an additional source of energy (diesel generator, wind power...).

NOTE 2 – The IEA PVPS guidelines recommend taking into account installations for both off-grid domestic and off-grid non-domestic systems. This has not been retained in the report.

At the end of 2006, off-grid photovoltaic systems amounted to 50 % of total power capacity while they are now under 1 %. Today, nearly all PV systems are connected to the electricity network.

In 2006, the government made the decision to promote photovoltaic energy in France by implementing the mandatory purchase of photovoltaic electric energy at an attractive price for the producer. The strategy was to encourage the use of photovoltaics on buildings. In a ministerial order issued 4 March 2011, the building integration concept was broken down into two categories: building-integrated systems (IAB) and simplified building-integrated systems

(ISB). Technical and non-technical requirements for IAB and ISB are presented in annex 2 of the order issued 4 March 2011.

1.1.2 **Statistical sources**

Data given in this report concern PV power installed during the 2013 calendar year and cumulative power capacity at the end of 2013. The installed power is divided into two main applications, off-grid and grid-connected. The grid-connected capacity is either distributed or centralized.

1.1.2.1 *Grid-connected system applications*

Data concerning grid-connected photovoltaic systems come from publications by the French statistics office SOeS (*Service de l'observation et des statistiques*, publications n° 498, February 2014 and n° 522, May 2014). SOeS statistics are derived from companies operating electricity transport and distribution (ERDF, RTE and EDF-SEI) and from main local distribution companies (ELD). The SOeS breaks down installed power data into different power categories and into 27 administrative regions.

Further data are also available, among which the report 'Overview of renewables in 2013' (*Panorama des énergies renouvelables 2013*) published in January 2014 by RTE, SER, ERDF and ADEeF. Volumes are somewhat different from those published by the SOeS. To avoid confusion this report refers to the SOeS data.

Data for installed volume of centralized ground-mounted applications are supplied by the Atlas Observer. The Atlas published by *Le Journal du photovoltaïque* (November 2013) lists photovoltaic installations with a power over 1 MW.

The volume of distributed applications (residential, industrial, agricultural or commercial roofs, PV shelters for car parks, etc.) has been assessed by calculating the difference between global installed volume reported by SOeS and the volume of centralized ground-mounted power plants from the Atlas. The results are shown in Tables 1, 3, 4, 5, 7 and Figure 1.

1.1.2.2 *Off-grid system applications*

Data for the volume of off-grid photovoltaic systems originate from the annual statistics of the Fund for rural electrification (FACE) and from companies operating in the sector, mostly in the French overseas departments.

1.2 **Installed power**

Reported volumes refer to photovoltaic systems installed in France during the 2013 calendar year, 'France' referring to metropolitan France with the island of Corsica and the overseas departments and regions (Guadeloupe, French Guyane, Martinique, Mayotte and Réunion).

1.2.1 **PV power commissioned in 2013**

The photovoltaic grid-connected power installed in France in 2013 (metropolitan and overseas) was estimated at 643 MW compared to 1 115 MW in 2012 and 1 770 MW in 2011 (source: SOeS). Grid-connected distributed systems, mainly building-integrated, reached 392 MW and centralized ground-based systems 251 MW (sources: SOeS, Atlas Observer and ADEME). Overseas departments and regions (DROM) accounted for 7 MW.

In 2013, off-grid applications were estimated at 0,1 MW (sources: FACE, ADEME and Sunzil).

Table 1 displays annual installed power in the three categories of application.

The financial investment linked to the activity in 2013 is estimated at 1,3 GEUR.

Table 1 – Photovoltaic power installed during calendar year 2013 (MW)

Grid-connected			Off-grid
Distributed	Centralized ground-mounted	Sub-total grid-connected	Domestic/Non-domestic
392 MW (61 %)	251 MW (39 %)	643 MW	0,1 MW

Sources: SOeS, Atlas Observer, FACE, ADEME, Sunzil.

Table 2 details grid-connected installations in different power categories in 2013. There was a 42 % drop in the grid-connected power compared to 2012. The decrease is much less marked in the number of installations, with a 13 % fall. Three quarters of total power installed within the year are systems over 36 kW and 89 % of the total number of installations are systems up to 9 kW.

Table 2 – Grid-connected installed capacity during calendar year 2013

Power range	Installation number (% of total)	Power (MW) (% of total)
0 – 3 kW	57,1 %	8,4 %
3 kW – 9 kW	31,6 %	10,3 %
9 kW – 36 kW	4,9 %	6,4 %
36 kW – 100 kW	5,9 %	26,0 %
100 kW – 250 kW	0,3 %	2,3 %
> 250 kW	0,2 %	46,8 %
Total	100 % (33 344 inst.)	100 % (643 MW)

Source: SOeS.

Over the period 2008-2013, 157 ground-mounted power plants with a unitary power over 1 MW were installed with a total capacity of 1 248 MW (Table 3, source: Atlas Observer, November 2013). The percentage of annually installed ground-mounted power plants went up from 25 % in 2011 to 39 % in 2013.

Seven ground-mounted power plants over 10 MW were commissioned in 2013. The largest plant (22 MW) was installed in the region of Aquitaine.

Table 3 – Power and number of centralized ground-mounted plants by power range

Power range	1 to 5 MW		5 to 10 MW		10 to 50 MW		> 50 MW		Total	
	MW	No.	MW	No.	MW	No.	MW	No.	MW	No.
2013	51	14	109	14	90	7	0	0	251	35
2012	26	10	5	1	198	10	115	2	344	23
2011	107	32	160	22	177	13	0	0	444	67
2010	32	14	36	5	101	4	0	0	168	23
2009	14	5	10	2	10	1	0	0	34	8
2008	0	0	7	1	0	0	0	0	7	1
Total	230	75	327	45	576	35	115	2	1 248	157

Source: Atlas Observer 2013; No.: number of projects.

By the end of 2013, there were 37 ground-mounted PV power plants over 10 MW, totalling 691 MW, the largest with 115 MW.

Table 4 shows the power installed annually between 2005 and 2013. The data for 2009-2012 have been adjusted in line with the latest information from the Atlas Observer and from SOeS. Data for 2013 are provisional and may be re-adjusted in a future edition.

Table 4 – Photovoltaic power capacity annually installed by application (MW)

Application	2005	2006	2007	2008	2009	2010	2011	2012	2013
Off-grid	1,1	1,5	1,0	0,4	6,3	0,1	0,1	0,2	0,1
Grid-connected distributed	5,9	9,4	36,6	97	151	667	1326	771	392
Grid-connected centralized	0	0	0	7	34	168	444	344	251
Grid-connected sub-total	5,9	9,4	36,6	104	185	835	1 770	1 115	643
Total (MW)	7,0	10,9	37,6	104,4	191,3	835,1	1 770,1	1 115,2	643,1

Sources: SOeS. A few figures from preceding IEA NSR France reports were reviewed to take into account the latest adjustments from SOeS, Atlas Observer and ADEME.

1.2.2 Cumulative PV power at the end of 2013

Table 5 shows the cumulative capacity at the end of 2013 broken down by system category: grid-connected (distributed and centralized ground-mounted systems) and off-grid.

Grid-connected cumulative PV capacity at the end of 2013, is estimated at 4 703 MW (318 924 systems), a 16 % increase compared to the end of 2012 (4 060 MW and 285 580 systems).

Ground-mounted power plants amount to 27 % of total grid-connected capacity. 70 % of total power is installed on buildings, either through total building integration (IAB) or simplified building integration (ISB). Added-on roof installations account for around 3 % of the total number of installations and most of them are found in French overseas departments.

Table 5 – Cumulative installed PV power at the end of 2013 (MW)

Grid-connected			Off-grid
Distributed	Centralized ground-mounted	Sub-total grid	Domestic and non-domestic
3 455 MW (73 %) (318 767 systems)	1 248 MW (27 %) (157 systems)	4 703 MW (318 924 systems)	29,7 MW

Sources: SOeS, Atlas Observer and ADEME.

Table 6 gives details of cumulative capacity at the end of 2013 by power category (SOeS statistics). Residential systems up to 3 kW represent 83 % of the total number of installations and 15 % of cumulative power whereas systems over 250 kW represent 0,3 % of the total number of installations and 44 % of cumulative power.

Table 6 – Grid-connected cumulative installed capacity as at end of 2013

Power range	Installation number (% of total)	Power (MW) (% of total)
0 – 3 kW	82,7 %	15,0 %
3 kW – 9 kW	8,5 %	3,4 %
9 kW – 36 kW	4,7 %	7,8 %
36 kW – 100 kW	2,2 %	11,3 %
100 kW – 250 kW	1,6 %	18,5 %
> 250 kW	0,3 %	44,1 %
Total	100 % (318 924 inst.)	100 % (4 703 MW)

Source: SOeS.

Table 7 displays cumulative power as at the end of December since 2005 according to the three categories mentioned above. The data published in the previous NSR France reports for IEA PVPS have been updated with the latest data from the SOeS and the Atlas Observer.

Table 7 – Cumulative PV capacity for each application as at the end of December (MW)

Application	2005	2006	2007	2008	2009	2010	2011	2012	2013
Off-grid	20,0	21,5	22,5	22,9	29,2	29,3	29,4	29,6	29,7
Grid-connected distributed	6	15	52	149	299	966	2 292	3 063	3 455
Grid-connected centralized ground-mounted	0	0	0	7	41	209	653	997	1 248
Grid-connected sub-total	6	15	52	156	340	1 175	2 945	4 060	4 703
Total (MW)	26,0	36,5	74,5	179	369	1 204,3	2 974,4	4 089,5	4 732,7

Sources: SOeS, preceding IEA NSR France. A few figures from preceding IEA NSR were reviewed to take into account the latest adjustments from SOeS, Atlas Observer and ADEME.

Figure 1 shows the evolution of national grid-connected photovoltaic power between 2006 and 2013 (annual installation volume and cumulative capacity at the end of each year).

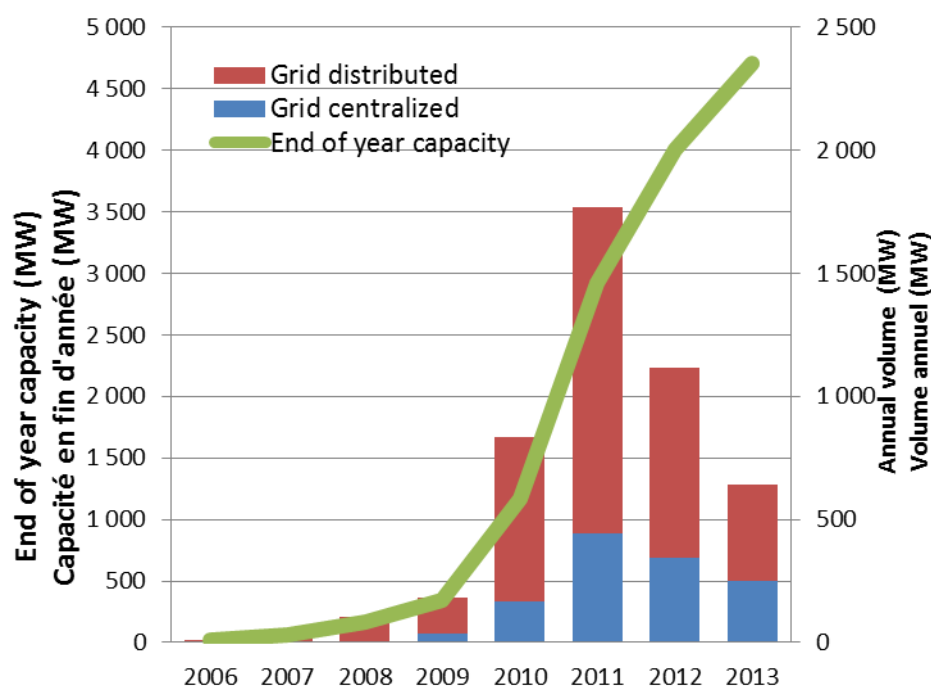


Figure 1 - Annual and cumulative capacity of grid-connected installations in France.

The main PV implantation areas in metropolitan France are the sunniest southern regions. Table 8 shows the six most active regions: they represent 61 % of total capacity and 54 % of the number of installations. In 2013, the annual power installed in these regions was close to three quarters of the power installed in metropolitan France (22 regions, 4 373 MW, 312 816 systems).

Table 8 – Main contributions of French Regions (metropolitan France)

Region	Cumulative installed capacity (% of total capacity)	Installation number (% of metropolitan France)	Grid-connected power during 2013 (% of total capacity)
Provence – Alpes – Côte d'Azur	15,2 %	7,3 %	22 %
Midi-Pyrénées	11,3 %	6,5 %	11 %
Aquitaine	11,2 %	7,6 %	11 %
Languedoc-Roussillon	10,0 %	7,9 %	17 %
Rhône-Alpes	6,9 %	13,1 %	6 %
Pays de la Loire	6,7 %	11,5 %	5 %
Total for 6 regions	61 % [2 668 MW]	54 %	73 % [443 MW]

Source: SOeS.

French overseas departments/regions (DROM) represent 7 % (331 MW) of total national PV capacity and 1,9 % of the number of installations (6 188 systems). The region of Réunion alone accounts for nearly 46 % of installed power in the DROM. A sharp drop in photovoltaic connection is to be noted in the overseas DROM and in Corsica, resulting from the intermittent energy limitation to 30 % of the total power. This limitation is imposed by EDF-SEI, the EDF division in charge of insular electricity networks.

1.2.3 Photovoltaic production and the energy market

Table 9 shows PV electricity production in relation to the electric energy market in metropolitan France (excluding the DROM) in 2013. All data come from the publication Electricity Report from RTE (*Bilan électrique 2013*) and are somewhat different from the SOeS statistics. PV electric energy production is estimated at 4,6 TWh, a 15 % increase on the previous year. Photovoltaic capacity represents 3,4 % of the total national power generation capacity. PV electric energy production covers 1 % of national electric energy

consumption. The annual average load factor is 13 %. In 2013, 51 % of new electricity generation capacity installed in metropolitan France come from photovoltaic systems installed during the year.

Table 9 – Photovoltaic power and the broader national electricity market

Cumulative PV capacity as a percentage of total electricity generation capacity	3,4 %
New annual installed PV capacity (2013) as a percentage of new electricity generation capacity	51 %
Total PV electric energy production as a percentage of total electric energy consumption	1 %

Source: *Bilan électrique RTE 2013*.

The publication 'Overview of REs in 2013' (*Panorama des énergies renouvelables 2013*) published by RTE, SER, ERDF and ADEEF gives a detailed analysis of each administrative region (production, load factor, rate of consumption). We can note that a peak of PV electricity generation capacity was reached at 14:00 on 21 August 2013 with 3 052 MW and that the average rate of consumption coverage reached a high of 7,3 % at 14:00 on 11 August 2013.

1.2.4 PV module technologies

The Atlas Observer provides details of the photovoltaic module technologies used for both categories of applications: distributed and centralized over 1 MW. Crystalline silicon modules account for 63 % of installed power whereas thin film modules stand at 37 % (Table 10). Data concerning systems between 0,1 MW to 1 MW published by Observer (Nov. 2013) confirm the prominence of crystalline silicon, but accurate information is currently unavailable for total installed PV capacity in France. Estimates suggest that crystalline silicon is the dominant technology at around 85 % of total installed PV capacity.

Table 10 – PV module technologies for systems over 1 MW

Module technology	Semi-conductor cell material	Power percentage
Crystalline silicon	Multicrystalline silicon (mc-Si)	38 %
	Single-crystal silicon (sc-Si) (also called monocrystalline)	25 %
Thin film	CdTe/CdS	35 %
	a-Si:H (and variants), CIGS	2 %

Source: Atlas Observer.

1.2.5 Trends in applications

1.2.5.1 Solar tracking, CPV, PV shelters for car parks

The first two national calls for tenders for PV systems over 250 kW, launched in 2011 and in 2013 have retained not only building-integrated systems and fixed-tilt ground-mounted power plants but also other applications such as ground-mounted power plants with solar tracking (target 200 MW), concentrator photovoltaic (CPV) power plants with a concentration factor of over 400 suns (target 80 MW) and PV shelters for car parks (about 200 MW).

1.2.5.2 Self-consumption

There is growing interest in the concept of self-consumption. Several technical and economic advantages are offered to the PV electricity producer, the grid administrator and the community at large. The SMEs of the sector welcome the opportunity for growth and job creation. Three Regions have issued calls for tenders for this type of applications.

In December 2013 the Ministry launched a public consultation on self-consumption issues.

2 ECONOMIC ASPECTS

2.1 Cost and profitability

In April 2014, the French Energy Regulatory Authority (CRE) published the analysis 'Costs and profitability of renewable energies in France'. Its objective was to ensure that public support financed by the CSPE would not generate excessive profit and that purchase tariffs were adapted to the sector. The study showed that the PV sector profit margin was clearly decreasing. Before the PV moratorium (December 2010) profitability was higher than the

weighted average cost of capital (WACC), and at times considered to be excessive. The implementation of calls for tenders in March 2011 was a successful step towards bringing profitability down to the WACC level of reference. The CRE recommended that calls for tenders should be maintained as well as periodically revised tariffs.

2.2 PV system price

The average turnkey price of installed building-integrated residential systems with European modules (IAB), is around 3,6 EUR/W. Simplified integrated installations (ISB) on commercial buildings stand at 1,9 EUR/W. The average turnkey price for ground-mounted plants is around 1,5 EUR/W (all prices indicated are exclusive of VAT).

Table 11 – Turnkey prices of typical applications (EUR/W) 2013

Category/Size	Typical applications	Average prices* (EUR/W)
Grid-connected IAB up to 3 kW	Residential building-integrated system	3,3 - 3,7 EUR/W
Grid-connected roof ISB < 36 kVA	Simplified building-integrated system	3,1 - 3,3 EUR/W
Grid-connected roof ISB 100 kW to 250 kW	Industrial, commercial agricultural large roof	1,8 - 2,0 EUR/W
Grid-connected ground-mounted > 2 MW	Centralized production, utility scale plant	1,4 - 1,6 EUR/W
Off-grid residential 3-5 kW (with storage battery)	Off-grid principal residence	10 - 15 EUR/W

Sources: ADEME, FACE, *VAT not included.

Table 12 – Trends in average turnkey prices for grid-connected applications (EUR/W)

Application	2007	2008	2009	2010	2011	2012	2013
Residential building-integrated IAB	8,4	8,2	6,9	5,9	3,9	3,7	3,6 EUR/W
Large commercial roof ISB	7,8	7,6	6,4	5,5	2,6	2,0	1,9 EUR/W
Centralized production Ground-mounted	6,3	6,2	5,2	4,5	2,0	1,6	1,5 EUR/W

Source: ADEME. VAT not included.

3 POLICY FRAMEWORK

3.1 General context

The French government's action plan towards renewable energy development targets at 23 % the percentage of renewable energy in energy consumption for 2020. In 2009, the Programming of investments (PPI) set a target volume of 5 400 MW for grid-connected PV applications by 2020.

In late 2010, the fast growing PV market led 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. It planned 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. Two categories: either the so-called 'simplified' for building-integrated installations with a power between 100 kW and 250 kW or the so-called 'ordinary' for larger installations with a power over 250 kW.

In early 2013, the Minister for Ecology introduced new measures in order to boost French PV activity. A volume of 800 MW a year was targeted until 2017 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) between 9 kW and 100 kW. The second segment of the annual target is allocated to calls for tenders of which 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.

3.2 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 funded by the Contribution to Electricity Public Services (CSPE), a fee paid by electricity consumers (see 4.2.1).

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

10 July 2006	Order introducing attractive feed-in tariffs for photovoltaic electricity (following the creation of a 50 % tax credit for households on the price of equipment in 2004).
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 adjustment for installations on buildings up to 100 kW and creation of a tender process for PV installations over 100 kW. Volume capped at 500 MW per year.
7 January 2013	Announced by the government in October 2012, the pricing structure is simplified (Table 14) and feed-in tariffs are increased by 5 % or 10 % for projects using photovoltaic modules manufactured in the European Economic Area (a measure applied from 1 Feb. 2013 to 10 March 2014). The annual volume is raised to 800 MW per year until 2017. New calls for tenders are introduced for systems over 100 kW (Table 15).

The pricing schedule of feed-in tariffs was simplified and modified by order of 7 January 2013 and came into force on 1 February 2013. From that date on, T1 tariff for building-integrated system (IAB) up to 9 kW applies whatever the use of the building (Table 14). T4 tariff for simplified building integration (ISB) applies up to 100 kW and T5 tariff covers all other types of installations up to 12 MW. An alternative to T5 tariff is to answer CRE's calls for tenders where electricity purchase price is set by project bidders.

The quarterly degression in feed-in tariffs is based on the number of grid-connection requests registered during the previous quarter. Feed-in tariffs are applied to either total or partial sale of electricity. The new measures impose a 20 % maximum cap on any annual degression in tariffs. For the first time in 2013, T4 tariff reached the 20 % limit.

Table 14 – Applicable PV feed-in tariffs as at Q1 2013 and Q4 2013 (EUR/kWh)

PV system type and tariff category	PV power (W)	Tariff* Q1 2013 (EUR/kWh)	Tariff* Q4 2013 (EUR/kWh)	Annual decrease (%)
T1 - Building-integrated photovoltaic systems (IAB)***	P ≤ 9 kW	0,3159	0,2910	7,9 %
T4 - Simplified building-integrated systems (ISB)***	P ≤ 36 kW	0,1817	0,1454	20 %**
	36 kW < P ≤ 100 kW	0,1727	0,1381	20 %**
T5 - Other type of installations	P < 12 MW	0,0818	0,0755	7,7 %

*Tariffs increased by 5 % or 10 % for modules manufactured in the European Economic Area. Validity until 10 March 2014.

**20 % cap on annual degression reached for the first time in 2013.

***Technical and non-technical requirements for building integration and simplified building integration are detailed in the 4 March 2011 order.

A new measure was introduced on 1 February 2013 for all applications (tariffs T1, T4, T5, see Table 14). All tariffs became eligible for a bonus of up to 10 % if the PV systems used modules manufactured in the European Economic Area: 10 % for full manufacture in EEA (crystalline silicon ingot/wafer, wafer/cell or cell/module; thin film module) and 5 % for partial manufacture in EEA (crystalline silicon cell or module). Since the European Commission considered that the tariff bonus was an obstacle to the free circulation of photovoltaic modules, the measure was withdrawn. However, the project applications for grid connection filed before 10 March 2014 could still benefit from the tariff bonus.

Feed-in tariffs are guaranteed for a period of 20 years as set by contract. Once fixed, feed-in tariffs are no longer affected by the quarterly degression. However, they are adjusted on an annual basis using a specific coefficient fixed by the National Organization of Statistics (INSEE).

EDF OA (*EDF Agence obligation d'achat*) and local distribution companies (ELD) are responsible for the financial side of these PV sales contracts. ERDF (*Électricité Réseau Distribution France*), in charge of the electricity network, draws up connection and access contracts for photovoltaic systems up to 36 kVA.

3.3 Sustainable development tax credit

Until the end of 2013 the private owners of PV systems up to 3 kW have benefited from a tax credit deductible from their income tax. The tax credit covering 11 % of the material cost was capped at 1 056 EUR. The measure ended on 31 December and VAT went up from 7 % to 10 % as of 1 January 2014.

3.4 Calls for tenders

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 early 2014. The CRE, in charge of regulating the electricity and gas markets, manages the national calls for tenders.

3.4.1 *Calls for tenders for 100 kW-250 kW systems*

Calls for tenders, so-called 'simplified', concern the construction and operation of photovoltaic installations between 100 kW and 250 kW. These installations have to comply with the rules governing simplified building integrated systems (ISB). The first series of calls was launched in 2011 with seven bidding periods totalling 300 MW, this target volume being divided into 120 MW for the first period and 30 MW for each of the following six periods.

At the end of 2012, the Ministry of Ecology (MEDDE) considered that the results were far from satisfying in terms of industrial achievements for the French PV sector. As a result, the last 5th and 6th periods previously scheduled for early 2013 were cancelled and replaced by a new call launched in 2013 for a total of 120 MW, divided into three periods of 40 MW each.

Projects were selected according to two criteria: the price that the bidder wished to charge for electricity supplied to the network over a period of 20 years (weight 2/3) and the carbon footprint assessment of the PV module manufacturing process (weighting 1/3). The results of the 3rd, 4th and 5th periods of the 2011 calls for systems of 100 kW to 250 kW were published in 2013. It should be noted that the first two periods analysed in a previous IEA report had resulted in selecting 66 MW, below the target volume previously set at 150 MW (Table 15).

The second series of calls launched in March 2013 slightly exceeded the initial target, for the first two periods P2.1 and P2.2, with a total power of 81 MW and 370 projects.

3.4.2 *Calls for tenders for systems over 250 kW*

Calls for tenders, so-called 'ordinary', concern the construction and operation of photovoltaic installations over 250 kW and up to 12 MW. The specifications for this type 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 the following: PV on buildings (ISB), ground-mounted power plants, PV shelters for car parks, concentrator photovoltaics and solar thermodynamics power plants. 105 projects for a total of 520 MW were selected, exceeding the initial objective by 70 MW.

A second call 'CRE 2 > 250 kW' was launched in March 2013 with a target of 400 MW. It concerned PV on buildings (140 MW), PV shelters for car parks (60 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). The tender specifications included the development of ground-mounted plants in degraded land (brownfields, old quarries or rubbish dumps...). They also required that environmental impact, industrial risks and the carbon footprint of frameless PV modules should be assessed. Each applicant was required to submit an R&D project. Over 350 proposals totalling a volume of more than 1,7 GW were declared eligible by the CRE well above the initial target of 400 MW. The official results of the call 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.

The third call for tenders CRE 3 > 250 kW is planned for mid-2014 with a target of 400 MW.

All in all, the calls launched in 2011, 2012, and 2013 with a targeted volume of 1 170 MW (not including calls P2.3 and CRE 3) resulted in the selection of 1 138 MW (1 352 projects) while more than 4 GW of projects were received by the CRE. The average price of electricity according to the different power categories and the different types of applications ranged between 200 EUR per MWh for the first calls and 140 EUR per MWh for more recent calls (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 periods (last 2 cancelled) 2011-08					
1 st period P1.1	L: 2011-08 DL: 2012-01	120 MW	S: 45,0 MW	S: 218	229* EUR/MWh
2 nd period P1.2	L: 2011-08 DL: 2012-03	30 MW	S: 20,9 MW	S: 109	211* EUR/MWh
3 rd period P1.3	L: 2011-08 DL: 2012-06	30 MW	S: 30,2 MW	S: 148	220* EUR/MWh
4 th period P1.4	L: 2011-08 DL: 2012-09	30 MW	S: 30,9 MW	S: 143	194* EUR/MWh
5 th period 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 periods (replaces 6th and 7th periods of preceding series) 2013-03					
1 st period P2.1	L: 2013-03 DL: 2013-10	40 MW	S: 40,3 MW	S: 177	168* EUR/MWh
2 nd period P2.2	L: 2013-03 DL: 2014-02	40 MW	S: 40,7 MW	S: 193	165* EUR/MWh
3 rd period P2.3	L: 2013-03 DL: 2014-06	40 MW	n/a	n/a	n/a
2 - 'Ordinary' calls: 250 kW - 12 MW Large roofs, ground-mounted plants...					
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 Under consideration	L: 2014-? DL: 2014-?	400 MW	n/a	n/a	n/a
Total (2011 - 2013) (excluding P2.3 & CRE 3)		1 170 MW (excl. P2.3 & CRE 3)	S: 1 137,9 MW (excl. P2.3 & CRE 3)	S: 1 352 syst. (excl. P2.3 & CRE 3)	

Source: CRE. *Weighted average calculated on eligible projects corresponding to different types of systems. Provisional value.

Table 16 lists the main call winners by order of power volume to be installed.

Table 16 – Main winners of 2012/2013 CRE's calls for tenders

CRE Calls for tenders 2012/2013	Main winning companies (by order of power volume to be installed)
1 st series P1.3 et P1.4 100 kW-250 kW	Tenesol/Sunpower, Générale du Solaire, Photosol, Langa Solar, Armorgreen, Facilasol, Urbasolar, Vienne Energies, ...
1 st series P1.5 100 kW-250 kW	Générale du Solaire (Vol-V, Sovafim, Prapec), Urbasolar, Tenergy, Mecojit, IEL Exploitation, Valsolar, Sun Premier, ...
2 nd series P2.1 100 kW-250 kW	Project volume ≥ 1 MW: JIT Solaire/Séolis, Irisolaris, Langa Solar, Klara Energies, Armorgreen, IEL, Urbasolar, Valeco, Arkolia Energies, Méthode Carré, Générale du Solaire ...
2 nd series P2.2 100 kW - 250 kW	Project volume ≥ 2 MW: Technique Solaire, Tenergy, Armorgreen, IEL, Facilasol...
CRE 2 > 250 kW	GDF-Suez (Compagnie du Vent, CNR), Urbasolar, Quadran, Valeco, Fonroche, Voltalia, Coruscant, Langa, Solairedirect et Enfinity... NOTE - Exosun, Heliotrop, Optimum Tracker and Soitec will participate in concentrator CPV plants and non-concentrator PV plants with solar trackers.

Sources: CRE, Greenunivers.

3.4.3 Calls for tenders by regional authorities

France's regional and departmental authorities are also carrying out photovoltaic promotion policies. A number of municipalities with diversified fields of action are also equally active. Enerplan union keeps up a comprehensive list of local authorities support measures. The regions of Alsace, Aquitaine and Poitou-Charentes have issued calls for tenders for

photovoltaic self-consumption projects. They aim to support the implantation of installations without any specific requirement regarding building-integration, with power of a few hundred kW and with a minimum of 70 % of self-consumed electricity. The beneficiaries could be local authorities, tertiary public or private sectors of activity and companies showing particular interest in energy efficiency. The financial support granted can be either an investment aid or a capped repayable advance. Preliminary studies can also receive financial support.

Private PV owners can also, in a number of cases, take advantage of local authorities' subsidies to finance their self-consumption projects up to 9 kW (with or without sale of surplus energy).

3.4.4 SRCAE and S3REnR regional plans

In 2012/2013, the regional authorities prepared provisional programmes on climate, air and energy (SRCAE). Around 15 GW of PV installations were planned for 2020. The regional schemes relating to renewable energy grid-connection (S3REnR) which already started in 10 different regions, aim at adapting and improving the electricity network. Each producer with an installation of over 36 kVA will have to contribute financially towards connection to the grid and its strengthening. The cost could reach as much as 70 000 EUR per MW. Professional trade unions have made comments and proposals to improve the relevance of the S3REnR schemes on three different points: elaboration method, planning of the reserved capacities and financing of investments.

3.5 Indirect policies

Different initiatives contribute to the development and promotion of photovoltaics in France.

3.5.1 Main competitiveness clusters

A competitiveness cluster brings together large and small companies, research laboratories and training centres on a well-defined territory and on a specific topic. The following three competitive clusters work on photovoltaics: Tenerrdis in Rhône-Alpes, Derbi in Languedoc-Roussillon and Midi-Pyrénées and Capenergie in Provence – Alpes – Côte d'Azur. Collaborative projects approved by the clusters are financed by the Interministerial Fund (FUI) or receive an 'Investment for the future' funding involving various partners such as ADEME, ANR or Bpifrance.

3.5.2 Professional organizations and associations

Professional trade unions ENERPLAN and SER/SOLER and such associations as ASDER, CLER, HESPUL, GPPEP and APESI have proved to be very active particularly in public debates and stakeholder consultations.

3.5.3 Events, exhibitions, conferences

In 2013, several events were organized to promote photovoltaic technology and its applications. Among them, the 14th SER colloquium (February 2013), the 2nd SER national colloquium on photovoltaic solar energy (May 2013), and the annual general meeting held by Enerplan for its 30th anniversary of solar energy involvement (September 2013). Professional trade fairs Bepositive/EnR at Lyon-Eurexpo (19-22 February 2013) and the 7th Energaïa edition in Montpellier (4-6 December 2013) have organized cycles of conferences and business meetings. A number of components manufactured in France have been particularly appreciated.

The 28th EU PVSEC European photovoltaic conference and exhibition was held at Paris-Villepinte (30 September – 4 October). Both the president and the vice president of the conference were well-known French personalities in industry and research. On that occasion, various workshops open to the public were organized by IEA PVPS and EPIA.

On the whole, there were fewer participants than in previous years but it was generally acknowledged that professional contacts were more productive.

The 6th edition of the European Solar Days managed by Enerplan and its partners (13-18 May 2013) organized 608 events for the general public.

A number of specific study days, colloquiums, training programmes and forums were set up by Enerplan and SER/SOLER, and by other actors such as Metrol, Tecsol, Transénergie or INES. The topics discussed included self-consumption issues, large scale integration of photovoltaics into the electricity grid, renewable energy financing, PV module reliability as well as support measures for renewable energies.

3.5.4 Export and Mediterranean initiatives

SER's mark 'France Solar Industry' brings together about 30 industries active in PV, CPV and solar thermodynamics sector. Its objective is to provide the French industry and more particularly SME-SMIs with some promotional support on the international market.

Several initiatives intend to promote cooperation and development over the whole Mediterranean region. Amongst the main projects of the *Union pour la Méditerranée* (UPM), the *Plan solaire méditerranéen* (PSM) aims at adding a capacity of 20 GW of renewable energy by 2020.

The Mediterranean Institute of Renewable Energy (IMEDER) is a group of professional organizations on both sides of the Mediterranean organizing many events such as conferences and exhibitions, for instance the 3rd RE Exhibition in Casablanca (Morocco, November 2013).

3.5.5 Thermal regulation

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 power market in France and it is only a step towards thermal regulation 'RT 2020', the so-called BEPOS (positive-energy building), under which new buildings will be net producers of energy.

3.5.6 Energy transition

In early 2013, the government introduced a major national consultation on energy transition pursued over the whole year. The topics on the agenda were energy sobriety, optimization of production systems, and increasing use of renewable energies. A bill on energy transition will be submitted to Parliament in the second half of 2014.

3.5.7 French and German cooperation

The purpose of the Franco-German renewable energies office (*Office franco-allemand pour les énergies renouvelables*) is to share experience and know-how between the two countries. The topics under discussion during the latest workshops were: 'Towards a European photovoltaic industry' and 'Integration of renewable energies into distribution networks'.

4 R&D HIGHLIGHTS AND BUDGETS

4.1 Main R&D programmes

In order to implement their policy of research and innovation, French ministries refer to agencies under their supervision such as ADEME (French Agency for Environment and Energy Management), ANR (French National Research Agency) or Bpifrance (organization providing support to SME-SMIs for their innovation projects). Research activities range from upstream studies (ANR's PROGELEC programme) to finalized projects (AMI PV programme

from ADEME) and industrial prototypes (reindustrialisation support programme of Bpifrance). These R&D projects are part of a government initiative called Investment 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 public/private partnerships.

ADEME runs nine projects in the R&D 'AMI PV' programme introduced at the end of 2009. These research projects aim at increasing the conversion efficiency of components as well as bringing down their manufacturing cost. Project results will be assessed in 2015.

In 2013, ADEME issued a call for proposals entitled 'Optimized integration of renewables and demand-side management'. It aimed at identifying issues arising from energy systems and obstacles to be removed. The deadline for responses was 21 March 2014.

At the beginning of 2014, ADEME issued two calls for expressions of interest (AMI). The first AMI on 'Renewable Energies' is intended to back up the development of new projects. The photovoltaic part of this AMI covers innovative processes and equipment for manufacturing materials, cells and modules. It also refers to the experimentation and validation of original photovoltaic systems and building integration technologies.

The second AMI call entitled 'Smart electrical systems' included research studies on the integration of distributed renewables into the grid.

ANR with the Progelec programme (Production and management of renewable electricity, 2011-2013) is active on PV research. The seven photovoltaic projects selected in 2013 come in addition to the ten projects already retained in the two previous years.

INES, the French National solar energy institute (a joint partnership of CEA, CNRS, CSTB and Université de Savoie) is the main organization in charge of R&D and training on solar energy. Its research activity on photovoltaics covers crystalline silicon (from feedstock material to cells), PV cell architecture and PV modules, organic materials, photovoltaic components and systems, storage and new applications development. In 2013, *Hélios*, a state-of-the-art positive energy building was inaugurated at its Bourget-du-Lac research centre. Since its creation seven years ago, about two hundred companies have signed partnership research contracts with INES.

IPVF (*Institut Photovoltaïque d'Île-de-France*) was set up by combining several public research teams from CNRS, École Polytechnique and private laboratories (Total, EDF, Air Liquide, Horiba Jobin Yvon and Riber). The partners will continue to push forward their research into thin film material, processes and equipment as well as advanced concepts on cells/modules with high conversion efficiency. IPVF belongs to the nine institutes for energy transition selected by the Ministry of Research. The construction of the new IPVF building on the Paris-Saclay campus was decided in October 2013.

Public research organizations CEA, CNRS and a number of Engineering School laboratories contribute to the RDI programmes funded by national organizations, such as ADEME and ANR. At European level some French research teams also take part in the FP7-ENERGY programme run by the European Commission. Regional Councils can also grant funding to industrial development projects.

In 2013, most research teams met together during two noteworthy events. The conference *Journées nationales du PV* (JNPV), organized by the CNRS and the Federation of PV laboratories (FedPV) took place in Dourdan near Paris (3 - 6 December 2013). Some of its sessions were transmitted over the Internet. The second event was the conference entitled 'Renewable energies in the service of humanity'. It was held at the UNESCO headquarters in Paris on 3 October 2013 at the very place where, 40 years ago, solar energy had received international recognition. This was the opportunity to revive the universal ambition of the 1973 Congress under the auspices of UNESCO, CNRS and ADEME.

4.2 Support budgets for PV market and R&D

4.2.1 Support budget for PV market

The French government has introduced two types of incentives to boost photovoltaic development in France: Feed-in tariffs and tax credits.

Feed-in tariffs: 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 2013, the CSPE amounted to about 1 800 MEUR (source CRE).

The CSPE is a fee paid by electricity customers according to the amount of electricity they consume. In 2013, the charge was standing at 13,50 EUR per MWh and raised to 16,50 EUR/MWh as of 1 January 2014. Its role is to balance the additional costs borne by electricity operators for their public service mission. Examples include: the additional costs incurred to ensure equal electricity rates for all French citizens (including overseas departments), specific pricing for people in difficult financial situation, and also the costs resulting from support measures for renewable energies and cogeneration.

Tax credit: Individual PV roofs owners up to 3 kW can take advantage of the sustainable development tax credit. In 2013, the cost of this measure was estimated at 19 MEUR.

4.2.2 Public R&D budget

In 2013, some new research and innovation projects received grant funding through public agencies ADEME, ANR and Bpifrance. RDI projects are funded through subsidies or repayable advances. Subsidies from ANR and ADEME amounted to about 4 MEUR in 2013.

5 INDUSTRY

All professions are represented in the French photovoltaic value chain. In the most upstream sector there are companies manufacturing 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.

SER union identifies 200 industrial companies across the PV value chain. This section focuses on PV materials and components and their manufacturing facilities located in France.

5.1 Silicon materials, ingots and wafers

The multicrystalline silicon sector (large-grain crystalline material) has historically been a technology favoured by French public authorities. Multicrystalline silicon ingots are elaborated by directional solidification (Photowatt/EDF ENR PWT, annual production capacity equivalent to 90 MW) or by semi-continuous casting in an electromagnetic cold crucible (Emix, pilot production). 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 of silicon ingots is equivalent to 80 MW.

An alternative to slicing ingot is being developed by two industrial projects. SolarForce works on the elaboration of silicon ribbon (RST process) and S'Tile manufactures silicon wafers by sintering silicon powder.

Studies on the preparation of silicon feedstock use the metallurgical method as opposed to the traditional chemical method: Ferropem/FerroAtlantica, Apollon Solar, INES and SIMAP/CNRS collaborate in developing a pilot production (Photosil).

5.2 Photovoltaic cells

5.2.1 Crystalline silicon PV cells

Photowatt founded in 1979 and owned by EDF ENR since March 2012 is France's long-standing vertically integrated manufacturer of multicrystalline silicon materials. Cells are prepared from thin wafers sliced from multicrystalline silicon ingots. Annual production capacity of photovoltaic cells is 95 MW.

MPO Energy develops an industrial project for manufacturing crystalline silicon photovoltaic cells using the ion implantation technique for the elaboration of the junction. The capacity of the metallization pilot line is 20 MW.

Irysolar, a subsidiary of OEM Semco Engineering, operates a pilot for manufacturing N-type silicon cells.

In 2013, the French annual production capacity of crystalline silicon cells was estimated at 135 MW.

5.2.2 Concentrator photovoltaic cells

Soitec SA develops multijunction photovoltaic cells GaInP/GaInAs/Ge with proprietary technologies. In 2013, in collaboration with Fraunhofer Institute and CEA, a quadruple junction cell has reached a record conversion efficiency of 44,7 % (concentration factor of 300). The concentrator photovoltaic cells are intended to be placed at the focal point of a light concentrator.

5.3 Photovoltaic modules

5.3.1 Crystalline silicon PV modules

The two long standing manufacturers of crystalline silicon modules are Photowatt (EDF ENR PWT) and Tenesol (now Sunpower).

Photowatt, 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.

The Total Group with its Sunpower subsidiary operates two module manufacturing plants in France and another one in the USA, using single-crystal silicon cells of high efficiency manufactured by Sunpower in Malaysia and the Philippines. The company boasts the highest conversion efficiency for its modules with 21,5 %.

In recent years, SME companies have started manufacturing photovoltaic modules based on imported crystalline silicon cells. In 2013, twelve companies were operating in France with an annual module production capacity of approximately 600 MW.

Table 17 lists PV module manufacturers in 2013 with a production facility located in France. Photowatt/EDF ENR PWT has not been included in this Table, since its modules were not manufactured on the French territory in 2013 (in line with the IEA PVPS report guidelines).

Table 17 – Crystalline silicon PV module manufacturers operating in France in 2013

Bosch Solar Energy*, Elifrance-Thomson, Fonroche Énergie, Francewatts, KDG Energy, Sillia Énergie, SNAsolar, Systovi, Sunpower/Tenesol, Total/Sunpower, VMH Énergies, Voltec Solar.

Source: SER. *the company changed hands in 2014.

Some of these companies manufacture photovoltaic laminates that can be mounted into frames adapted to building-integration. Others develop photovoltaic thermal hybrid modules (PV/T).

The German Bosch Group decided to stop its crystalline silicon activities in March 2013. Its French PV subsidiary continued to produce modules up to the end of 2013. The activity was taken over by module manufacturer Sillia Énergie in partnership with Urbasolar (early 2014).

5.3.2 Thin film modules

Two companies are involved in the development of thin-film module production lines.

SolSia associated with Solems (small power modules), is developing a production pilot for large area modules made from amorphous silicon and its variants (PECVD technique). Nexcis is working on a pilot line for the industrialization of CIGS based modules. The technique involves the electrodeposition of copper, indium and gallium, coupled with annealing in a sulfur and selenium atmosphere. This process was initially researched into by the IRDEP joint research Institute (EDF and CNRS). The modules are either glass/glass or metal/polymer.

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

5.3.3 Concentrator modules, solar trackers

Concentrator photovoltaics (CPV) was one of the PV applications retained by CRE's calls for tenders (target 60 MW). The following companies participate in projects selected by CRE's calls.

Heliotrop is developing photovoltaic modules of the third generation with 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 SA is working on concentrator photovoltaic cells (see 5.2.2) and operating a concentrator module production line in San Diego (US). Both Soitec and Heliotrop, in partnership with Exosun, participate in the construction of CPV plants totaling around 50 MW (CRE's calls).

Exosun designed and built the first PV plant equipped with solar trackers in France in 2008. The projects were developed by gradually increasing power over the years. In 2013, in partnership with Urbasolar, a 4,7 MW plant with single-axis trackers was grid-connected. Six PV plants ranging from 6 MW to 12 MW were to be grid-connected in 2014.

Optimum Tracker is specialized in the design and development of solar trackers. The small company finalized its first contracts for the construction of two ground-based solar power plants with a total power of 17 MW. Construction will be completed by June 2014.

5.3.4 PV product recycling

Several French players in the photovoltaic sector have come together to set up PV CYCLE France SAS, a subsidiary of PV CYCLE, the European Association specializing in the collection and recycling of PV modules. The former French association CERES ceased operation in 2013 passing on its know-how and members to PV CYCLE France.

5.4 Manufacturers and suppliers of other components

Some companies produce the machine tools and equipment needed for manufacturing silicon ingots, cells and modules. Other companies, some of which are leaders in their field, produce materials for industry (gas, glasses, polymers, graphite, ceramics...).

Many major French companies supply a full range of electrical materials and equipment used in the connection, control, measurement and monitoring of photovoltaic systems. Several French companies have developed ranges of inverters some of which have

attracted special attention in trade fairs in 2013 along with other products. Many of these companies are present on both the domestic and export markets.

The feed-in tariffs granted to building-integrated systems have encouraged companies to develop specific components. A number of firms manufacture and supply building integration products (IAB and ISB). They may apply for technical assessment certificates such as ATec PV or a *Pass'Innovation Vert* from CSTB or for ETN technical assessments (assessment of new technique).

5.5 Actors in the downstream sector

The installation sector encompasses a large number of companies. The sector is highly heterogeneous. It is estimated that around 80 % independent professional installers only complete one or two installations a year, while around a thousand others manage to install between 10 and 20 systems. A few dozen large companies install one third of all systems (source ADEME).

Installers can refer to such quality labels as Qualibat, Qualifelec, Qualit'EnR, QualiPV, etc. drawn up by professional bodies. From 1 July 2014, home owners must call on qualified professionals stamped with the RGE label (Recognized guarantor of the environment, see 8.3.3).

Developers/designers/operators are very active. Indeed, the latest CRE tenders met with significant interest as shown by the volume of eligible projects which amounted to four times the Ministry's initial target volume (see Table 15 and Table 16).

6 PV IN THE ECONOMY

6.1 Employment

The PV full-time equivalent (FTE) jobs taken into account here are in component manufacturing, engineering studies and installation, excluding public R&D.

Their total number was estimated at 10 130 in 2013 against 16 800 in 2012 (source: ADEME). The drop in employment is directly related to the slowing down of activity in installation companies, the main source of jobs in the sector.

Jobs related to energy production have slightly increased from previous years and were estimated at 2 000 in 2013 (1 660 in 2012).

In 2013, French PV activity represented approximately 12 130 FTEs (18 460 in 2012), (Table 18)

Table 18 – PV employment 2013 (full-time equivalent)

Jobs related to the development of the sector (component manufacturing, engineering studies and installation, excluding public research)	10 130
Jobs related to PV energy production	2 000
Total	12 130

Source: ADEME (provisional).

6.2 Value of PV production

In 2013, total investment for the PV sector amounted to around 1,3 GEUR. The value of annual production of the French photovoltaic sector was estimated at 925 MEUR, a 34 % decrease over the previous year (Source: ADEME).

7 INTEREST FROM ELECTRICITY STAKEHOLDERS

The two major energy companies EDF and GDF SUEZ along with their subsidiaries are significantly involved in the development 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 new solutions to integrate renewables into the network.

7.1 EDF Group

EDF EN (EDF Énergies Nouvelles) is a subsidiary of French utility EDF and was created in 1990. EDF EN develops, builds and operates renewable energy plants in Europe and North America. By end of 2013, 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 created in 2007. Along with its two subsidiaries EDF ENR SOLAR and EDF ENR PWT (Photowatt), EDF ENR considers itself as the only French company present along the whole PV value chain including R&D:

- EDF ENR SOLAR provides PV systems for all types of roofs including individual housing, agricultural, industrial and administrative buildings, together with supervision and maintenance (more than 12 000 installations).
- EDF ENR PWT (Photowatt) manufactures crystalline silicon ingots, wafers, cells and PV modules (see 5.2.1 and 5.3.1).

7.2 GDF SUEZ Group

Along with its subsidiaries, GDF SUEZ operates as systems integrator and as main contractor of turnkey projects for private and institutional investors. Its subsidiaries such as La Compagnie du Vent, La Compagnie Nationale du Rhône-CN'Air or Inéo, claim a capacity of 149 MW either in operation, construction or advanced development (objective 200 MW in 2016).

7.3 Other companies and RE producers

The 3rd largest electricity producer E.ON France operates 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 region of Poitou-Charentes, Solairedirect SA and electricity supplier Séolis.

In 2013, the companies commissioning PV power plants over 2 MW for a total of 253 MW were the following: Bouygues, Cegelec/SDF, EHTP/Spie, Eosol EN/TSK, GDF Suez, Ineo, Jayme da Costa, La Compagnie du Vent, Juwi Renewable Energy, Luxel SAS, Siemens, Solairedirect, Urbasolar and Valeco Engineering (source: Atlas Observer 2013).

7.4 Grid operators

Transmission and distribution operators are exploring ways to ensure the safety of the electrical distribution system. RTE (*Réseau de transport d'électricité*) has developed real-time monitoring of renewable electricity production. French grid operator ERDF and local distribution companies (ELD) are currently looking into ways to optimize the management of constraints.

8 STANDARDS AND CODES

8.1 PV Standards

France does not develop its own PV standards but adopts those prepared by International Electrotechnical Commission IEC and by European organization CENELEC.

French National PV standardization committee AFNOR/UF 82 is the mirror committee of IEC and CENELEC TC 82. UF 82, with its 29 experts, participates in the vote of acceptance of IEC and CENELEC Standards after comments and amendments. Standards once voted upon are translated into French through AFNOR. Standards are then incorporated into the French Standard NF system and display the NF EN prefix as in NF EN 61215.

In 2013, the International Standards translated into French were the following: Overall efficiency of inverters (EN 50530: 2010/prA1); Junction boxes for PV modules (EN 50548: 2011/prA1, IEC 62790 Ed.1); Module safety qualification (IEC 61730-1 am2 Ed.1) and Ammonia corrosion testing of PV modules (IEC 62716 Ed.1). Two Standards related to new activities in France were being translated at the time of report writing: 'Solar tracker design qualification (IEC 62817 Ed.1)' and 'Specification of concentrator cell description (IEC TS 62789 Ed.1)'.

8.2 Technical Guides

Some new publications were published during 2013. The significant document 'Photovoltaic systems without storage and connected to the public distribution network' (UTE C 15-712-1) was updated in July 2013. At the same time, a new publication was released on photovoltaic off-grid systems 'Stand-alone photovoltaic systems not connected to the public grid and with battery storage' (UTE C 15-712-2). The document 'Managing risk in photovoltaic installations' gives advice to firefighters working in 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 dismantled their PV arrays preventively.

The French Building Federation PV branch has published a number of technical guides such as 'Description of work specifications', 'Performance and energy consumption' and, 'Rules of conduct of PV in the building sector'.

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

8.3 Qualification and quality marks

8.3.1 Testing and certification

CERTISOLIS TC, a subsidiary of CSTB and LNE is a COFRAC accredited laboratory which works on photovoltaic module testing and certification. CERTISOLIS certifies that PV modules comply with NF EN 61215 (crystalline silicon) or NF EN 61646 (thin film) and Class II electrical safety according to Standard NF EN 61140 or NF EN 61730. Tested modules bear the Certisolis MPV mark, which not only guarantees their conformity with applicable Standards, but also indicates that they annually undergo a quality audit for their design and manufacture.

Since the release of the order dated 7 January 2013 regarding the electricity tariff bonus by 5 % or 10 %, Certisolis and some other accredited organizations have conducted audits to attest that the PV modules were manufactured within the European Economic Area (this tariff bonus was implemented between 1 February 2013 and 10 March 2014).

8.3.2 Technical approval

In 2008, the CSTB (Scientific and Technical Centre for Building) 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. This is a simplified evaluation that can be obtained faster than an Atec PV. It is valid for a maximum period of 2 years allowing time to collect the necessary documents and to acquire sufficient feedback before applying for ATec. End of 2013, approximately 32 ATec PV and 55 *Pass'Innovation Vert* were still valid.

Some products and processes used in the PV building sector can also be evaluated through an Assessment of new technique (ETN). An ETN is issued by a registered inspector relying on the information provided by the manufacturer.

8.3.3 Quality labels

Professional associations and administrative authorities have developed a range of recommendations and quality labels to promote products and services quality. In 2013, the French Directorate for Competition, Consumer Affairs and Fraud Control (DGCCRF) conducted a study on the marketing and financing conditions for the installation of photovoltaic roofs. One third of the 139 professionals under survey did not comply with the established rules on these issues. This prompted DGCCRF to recommend the utmost vigilance in case of sales prospecting.

8.3.3.1 RGE label

As from 1 July 2014, homeowners wishing to receive public subsidy will have to call on qualified professionals stamped with the RGE label (*Reconnu garant de l'environnement*). This label indicates that the installers' work is in compliance with all professional PV quality labels and the mandatory decennial liability requirements.

8.3.3.2 Qualit'EnR, QualiPV

Qualit'EnR is a certified association specialized in labelling renewable energy (RE) 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 labels such as Qualibat (EE/ENR) or Qualifelec (SPV).

8.3.3.3 AQPV

Photovoltaic quality Alliance (AQPV, *Alliance Qualité Photovoltaïque*) is a mark managed by SER (Renewable energy union). It certifies the quality of PV modules (AQPV-Modules) and of operator services (AQPV-General Contractor).

9 HIGHLIGHTS AND PROSPECTS

With 643 MW grid-connected in 2013, total photovoltaic capacity rose by 16 % to reach 4 703 MW with 318 924 systems. Annual PV production now covers 1 % of national electric energy consumption. The initial target of 5,4 GW set up by the French government for 2020 should be soon exceeded.

The French photovoltaic sector development is mainly driven by the government's feed-in tariff policy. At the beginning of 2013, the Minister for Ecology made the decision to double the annual volume of installations and to simplify the pricing schedule, notably for simplified building-integrated systems (ISB). Some new calls for tenders were launched for systems over 100 kW with a two-year target volume of 920 MW. The industry welcomed these

announcements. It should be noted that since 2011, national calls have gained in popularity: operators filed a volume of projects four times higher than the ministry's set target. However, the industry expressed concern when informed that the new tariff bonus for photovoltaic modules manufactured in the E.E.A. would be suppressed after one year of implementation and that the tax credit would be cancelled by the end of 2013.

Photovoltaic module manufacturers and small installers are the most exposed to the sector's difficulties, and yet some large groups and independent operators have managed to maintain their activity by responding to national/regional calls for tenders and by developing projects abroad.

During the preparation phase of the energy transition law due to be voted in 2014, the unions and associations suggested implementing fixed feed-in tariffs and maintaining calls for tenders for PV systems over 100 kW.

In the years to come, French Regions should play an important role in photovoltaic development with a planned total volume of around 15 GW by 2020. The industry maintains the objective of 20 GW to be achieved by 2020.

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ANNEX A COUNTRY INFORMATION

This Annex provides additional information regarding France and parameters linked to its electricity system.

1. **France**
(French Republic)

France = Metropolitan France (continental France + Corsica Island), 22 Regions + overseas department/region (Guadeloupe, Guyane, Martinique, Mayotte, Réunion).
Population (metropolitan France): 64 million
Area (metropolitan France): 552 000 km²
Area overseas (DOM): 89 000 km²
2. **Electricity generating capacity** (all power stations, including PV) installed in metropolitan France at the end of 2013

Total power: 128 GW of which:
Nuclear: 63 GW; Fossil fuel: 26 GW; Hydro: 25 GW; Wind: 8,1 GW; **PV: 4,3 GW**; Other RES: 1,5 GW.
NOTE – RTE PV figures differ from SOeS PV statistics.
(Source: RTE Electricity Report 2013)
3. **Total electricity consumption and production** 2013 in metropolitan France

Total consumption (2013): 476 TWh
Total production (2013): 551 TWh (+ 1,7 %/2012) of which Nuclear 404 TWh; hydro: 76 TWh; Fossil fuel: 45 TWh; Wind: 16 TWh; **PV: 4,6 TWh**; Other RES: 6,3 TWh.
PV: 1 % of consumption.
(Source: RTE Electricity Report 2013)
4. **New electricity generating capacity** (all power stations, including PV) installed in metropolitan France during 2013

+ 1 461 MW with **PV: 51 %**; Wind: 43 %; Other RES: 6 %.
[Gas: - 71 MW; coal: - 1 573 MW; fossil fuel: - 607 MW; Hydro: - 3 MW; Nuclear: 0 MW]
NOTE – RTE PV figures differ from SOeS PV statistics.
(Source: RTE Electricity Report 2013).
5. **Average final annual yield in France (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.
6. **Retail electricity prices**
 - household: 0,1472 EUR/kWh
 - industry: 0,0771 EUR/kWh
7. **Major electricity utilities**
(Metropolitan France)

EDF (Électricité de France): 97 GW, 89 % customers (total 36 million), GDF-SUEZ: 10 GW, E.ON France...
8. **Transport**

RTE (Réseau de transport d'électricité).
9. **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 et Sorégies...

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