# The photovoltaic sector in France

Year 2009

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# Foreword

The International Energy Agency (IEA), founded in November 1974, is an autonomous body within the framework of the organisation for Economic Cooperation and Development (OECD), which carries out a comprehensive programme of energy cooperation among its 23 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 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 nineteen participating countries are Australia (AUS), Austria (AUT), Canada (CAN), Denmark (DNK), France (FRA), Germany (DEU), Israel (ISR), Italy (ITA), Japan (JPN), Korea (KOR), Mexico (MEX), The Netherlands (NLD), Norway (NOR), Portugal (PRT), Spain (ESP), Sweden (SWE), Switzerland (CHE), The United Kingdom (GBR) and The United States of America (USA). The European Commission is also a member. The European Industry Association (EPIA) is an associated partner.

The overall programme is headed by an Executive Committee composed of one representative from each participating country, while the management of individual research projects (tasks) is the responsibility of Operating Agents. Eleven tasks have been established, and currently six are active including a new task concerning environmental impacts. Information about these tasks can be found on the public website <u>www.iea-pvps.org</u>.

# Introduction

As part of the International Energy Agency's Photovoltaic Power Systems Programme, the no.1 working party's aim is to collect data from each of its member countries so as to put together an annual report. This report is published under the title of *Trends in photovoltaic applications*.

This document serves as France's contribution to this report.

This version will be approved by ADEME and then translated into English. It will then be uploaded onto the IEA PVPS website at <u>www.iea-pvps.org</u>.

The 2009 national survey report for France presented here is prepared by Mr Philippe Jacquin, consultant (<u>www.phkconsultants.com</u>) and by Mr Yvonnick Durand, from ADEME (Agence De l'Environnement et de la Maîtrise de l'Energie) (<u>www.ademe.fr</u>), IEA/PVPS/Task 1 participant.

# Definitions, symbols and abbreviations

For the purposes of the report, the following definitions and symbols apply:

BIPV: building integrated photovoltaic(s)

EUR: euro currency unit (ISO code). MEUR means million euro (10<sup>6</sup> EUR).

<u>Demonstration programme</u>: a programme to demonstrate photovoltaic systems and their application for potential users/owners.

<u>Field test programme</u>: a programme to test the performance of photovoltaic systems/components in real conditions.

Final annual yield: total photovoltaic energy delivered (kWh) during the year per unit (kW) of rated (STC) power.

<u>Grid-connected distributed photovoltaic system</u>: system installed to provide electricity to a gridconnected customer or directly to the electricity network (specifically where that part of the electricity grid is configured to supply power to a number of customers rather than to provide a bulk transport function). Such systems may be either integrated or on the roof of the customer's premises often on the demand side of the electricity meter, on public and commercial buildings, or simply in the built environment on motorway sound barriers etc. They may be specifically designed to support the utility distribution grid. Size is not a determining feature – while a 1 MW photovoltaic system on a rooftop may be large by photovoltaic standards, this is not the case for other forms of distributed generation.

<u>Grid-connected centralized photovoltaic power system</u>: power production system performing the function of a centralized power plant. The power supplied by such a system is not associated with a particular electricity consumer, and the system is not located to specifically perform functions on the electricity grid other than the supply of bulk power. They are normally installed at ground level and function independently of any nearby development.

Installed photovoltaic (PV) power: power delivered by a photovoltaic array under standard test conditions (STC). Also see 'Rated power'.

<u>Market deployment initiative</u>: set of measures to encourage the market deployment of photovoltaics using market instruments such as green pricing, rate based incentives, feed-in tariffs, tax credits, etc. These may be implemented by government, the finance industry, utilities, etc.

Module manufacturer: a company which produces PV modules via PV cells encapsulation.

<u>Off-grid domestic photovoltaic system</u>: system installed to provide power mainly to a household or village not connected to the (main) utility electricity grid(s). Is often connected to an electricity storage device (most commonly lead-acid batteries). Also referred to as 'stand-alone photovoltaic power system'. Can also provide power to domestic and community users (and for other applications) via a 'mini-grid', often in association with another source of power (hybrid system).

<u>Off-grid non-domestic photovoltaic system</u>: 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. Is often connected to an electricity storage device. Also referred to as 'stand-alone photovoltaic system'.

<u>Performance ratio:</u> ratio of the final annual (monthly, daily) yield to the reference annual (monthly, daily) yield, where the reference annual (monthly, daily) yield is the theoretical annual (monthly, daily) available energy per unit (kW) of rated (STC) power.

<u>Photovoltaic (PV) system</u>: set of interconnected elements such as photovoltaic modules, inverters that convert d.c. current of the modules into a.c. current, storage batteries and all installation and control components with a rated photovoltaic power of 40 W or more.

<u>Photovoltaic (PV) system market</u>: the market for all nationally installed (terrestrial) photovoltaic applications with a photovoltaic power capacity of 40 W or more.

<u>PV</u>: abbreviation of photovoltaic (adj.) or photovoltaics (noun).

<u>Rated power</u>: available power delivered by a photovoltaic module, a photovoltaic panel or a photovoltaic array under standard test conditions (STC). Unit written as W (multiple: kW, kilowatt, MW, megawatt).

<u>STC</u>: standard test conditions (irradiance of 1 000 W/m<sup>2</sup>, cell junction temperature of 25 °C, AM 1,5 solar spectrum).

<u>Turnkey price</u>: price of an installed photovoltaic system excluding VAT sales taxes, operation and maintenance costs but including installation costs. For an off-grid photovoltaic system, the prices associated with storage battery maintenance/replacement are excluded. If additional costs are incurred for reasons not directly related to the photovoltaic system, these should be excluded. (e.g. if extra costs are incurred fitting photovoltaic modules on a factory roof because special precautions are required to avoid disrupting production, these extra costs should not be included. The additional transport costs of installing a telecommunication system in a remote area are also excluded).

NOTE – The currency unit used throughout the report is the euro (EUR). Other units are euro per watt (EUR/W), euro per kWh (EUR/kWh), kilowatt-hour per unit (kWh/kW) of installed photovoltaic power (kW).

# 1 Executive summary

#### • Overview of the sector

According to statistics drawn up in 2009 by the *Syndicat des Energies Renouvelables* (SER, France's professional association of bodies involved in renewable energies), 250 MW of generating capacity were added during the year. This brings France's total installed photovoltaic capacity up to 430 MW.

France's photovoltaic market grew from the world's 12<sup>th</sup> largest in terms of market size to 7<sup>th</sup> largest by the end of 2009. This was due to growth that was sustained by high feed-in tariffs and a drop in the price of equipment.

The broad guidelines which followed on from the legislation that emerged from the "Grenelle of the Environment" are influencing the ways in which the market is to grow over the next few years:

- a target of 1100 MW of photovoltaic installed capacity by 2012, reaching 5 400 MW by 2020;
- confirmation that tariff incentives will remain in place until 2012 and creation of an additional tariff for photovoltaic installations in large-sized buildings, such as commercial premises and industrial warehouses. This tariff has been fixed at 0,45 EUR per kWh; however, adjustment measures were announced at the end of 2009 to reduce a speculative approach that could ultimately lead to an hardening of access conditions to the higher tariffs.
- the issuing of an invitation to tender for the construction of a least one photovoltaic power plant per region in France by 2011, providing a total of 300 MW of power.

2009 was mainly marked by an increase in the number of medium- and high-power plants, together with the emergence of a number of new organizations in the photovoltaic sector.

The market continues to be strongly influenced by the priorities given to the integration of photovoltaics into buildings. The effects of the incentive measures that have been in place since 2006 (feed-in tariffs and fiscal measures) are still being felt. They continue to stimulate investment - both from private individuals and manufacturing organizations.

In other respects, growth has resulted from a significant fall in the price of equipment (-30% over the entire year, according to a survey that was conducted by companies involved in the field).

In the manufacturing sector, a number of new operators are emerging and the sector's value chain is gradually being built up. As of the end of 2009, there were approximately 210 MW of crystalline module production capacity, with a number of projects underway to either create or extend existing production installations over the next couple of years. Several projects to develop thin-film modules were also set up. There are currently 10 module manufacturers across the country. Around 10 more companies are intending to set up module manufacturing facilities.

And a further 150 or so companies are involved in building the other components which make up photovoltaic systems (structure, inverters, solar equipment, etc.).

There are also numerous installers and project developers emerging downstream of the value chain. Actions for certification have been considerably developed. As a result, the number of Quali'PV-approved installers more than doubled in 2009, and now stands at more than 5600 companies.

With regard to employment, the SER estimated that as of mid-2009, the number of jobs in component manufacturing and system installation that were directly generated by the sector stood at 8 500. This is a dramatic increase on the previous year (approximately 4 500).

The procedures for handling requests to be connected up to the national network have been simplified and wait times reduced. However, as of the end of December 2009, around 58 127 systems were awaiting connection in mainland France, which would provide a total installed capacity of 2 537 MW. In addition, 2 283 requests (901 MW) were outstanding throughout France's overseas territories and Corsica, according to a breakdown provided by national distribution grid operator ERDF.

Initiatives being implemented at national level are being coordinated by public fundings from regional councils', general councils, joint municipal authorities and communes depending on specifications.

The ADEME (the French Agency for Environment and Energy Management - www.ademe.fr), together with the ANR (France's national research agency - www.agence-nationale-recherche.fr), the OSEO (company financing body for projects to create, innovate and develop - www.oseo.fr) and France's regional councils are continuing to support research activities in the field of photovoltaics.

### Generating capacity

During the course of 2009, 220 MW were installed in mainland France and a further 30 MW across its overseas territories, making for a total of 250 MW (105 MW in 2008). According to the Enerplan Association, the total photovoltaic power capacity installed in France has now reached 430 MW. In view of the discrepancies between the total capacity installed and the power connected to the national grid (due to delays in handling connection requests), the total photovoltaic power capacity connected up to the French grid was 269 MW as of the end of 2009, with an annual production estimation of 290 GWh.

The residential market continues to grow (+225% compared with 2008), driven by incentives such as feed-in tariffs and fiscal measures.

Nearly 40% of the total capacity installed in mainland France in 2009 involves large-scale roofmounted modules: these include large surface-area farm buildings, which are particularly sought after.

Growth in the numbers of ground-based power plants which began over the two previous years continued into 2009 with a number of projects, totalling some 60 MW of installed capacity. There is a significant time-lag between projects being launched and their actual implementation. This can be attributed to technical development time and to administrative procedures being longer than for other segments of the market.

The "off-grid" installation market - the original basis for the photovoltaic market in France - has shrunk considerably. Total installed power capacity in 2009 was approximately 200 kW.

#### • Price levels

On the basis of interviews carried out with manufacturers and installers, the prices of the various types of on-grid installations are as shown in Table 1.

Installation examples	Example of installed power (kW)	Price of installed system (EUR/W not including tax)
Residential roofs	~3	5,5 to 6,5
Building roofs	~ 10 to 100	4,5 to 5,5
Large manufacturing facility roofs	~250 to 500	3,6 to 4,4
Ground-based plants	~1000	2,7 to 3,1

### Table 1 : Price levels of installed photovoltaic systems (2009)

With prices having fallen by an estimated 30% during the course of 2009 (compared with 2008), the price of modules in France, not including tax, varies between 1,10 EUR/W and 1,30 EUR/W for components made in China, and between 1,50 EUR/W and 1,90 EUR/W for components made in Europe or Japan.

### • Cell and module production capacity

In 2009, companies with production units based in France totalled approximately 60 MW of cell production capacity, and approximately 210 MW of crystalline production capacity and 1,2 MW of amorphous silicon.

A number of projects involving CIGS and CdTe thin-film technologies are underway.

### Public R&D funding

The ADEME is the body which has always financed initiatives to develop and promote the use of photovoltaic power in France. Since 2005, a number of new initiatives at both national and regional level have supplemented the ADEME's scope of involvement. The setting up of the French National Research Agency (ANR) and the industrial development agency (OSEO) has increased the various R&D initiatives.

Since 2005, the ANR has been giving 8,5 MEUR per year to support photovoltaic projects (10 to 12 projects per year), to aid the development of emerging sectors and to encourage public/private partnerships.

As part of the HABISOL project launched in 2008, the ANR chose to merge construction and photovoltaic research programmes in order to highlight the importance of integrating photovoltaic technology into buildings.

In February 2009, the European executive authorised France to give 46,5 MEUR worth of state funding to the Solar Nano Crystal programme (2008-2012). The general aim of this project is to group together various different industrial partners and R&D units within the PV Alliance consortium so as to reduce production costs, increase photovoltaic conversion efficiency and minimise the environmental impacts of the production processes of silicon based technologies.

The ADEME is also giving its support to R&D initiatives (5,4 MEUR). These include R&D projects to develop solutions for integrating photovoltaic modules into existing buildings (RESSOURCES programme). It is also supporting demonstrators programmes. Elsewhere, it is continuing to support programmes to provide project implementers with training (PHOTON and PHOTON RESEAU training sessions). At international level, the ADEME is continuing its involvement in shared-cost projects within the International Energy Agency, particularly in working groups 1, 2, 9, 10, 11 and 12 of the PVPS. The International Electrotechnical Commission receives contributions from French teams supported by the ADEME, particularly for drawing up technical specifications for using renewable energy sources to provide rural communities with electricity. (IEC 62257 specifications series).

As part of the renewable energies development plan that was presented in November 2008 by the Ministry for energy, the Energy Regulation Commission issued a call to tender for the construction of a solar power plant in each of the country's regions by 2011. This should provide a total of 300 MW and will be divided into 4 geographic areas. The first projects are in the process of being defined.

As of 2009, three national "competitivity clusters" set up in 2005 (in the Languedoc Roussillon, Provence Alpes Côte d'Azur and Rhône Alpes regions) manage the various initiatives in the process of being implemented by 40 research centres, 30 training centres and nearly 150 companies involved in solar power and energy efficiency in buildings. They coordinate work carried out in 4 different strands of research: innovative concepts, the manufacture of components, systems and performances characterization.

In its information report submitted in July 2009, the Economic Affairs Committee of France's National Assembly drew up 9 guidelines that a national programme to develop the photovoltaic sector should follow:

- Prepare the falling due of the grid parity (adjustment of tariffs)
- Prevent conflicts in usage and uptake of arable land for solar power plants (eligibility criteria of ground for hosting power plants)
- Integrate the growth of the photovoltaic sector and urban development (regionalisation of tariffs and geographical balancing of infrastructure)
- Support building integration as a development path for the sector in France (qualification of building integration conditions, tariff adaptation)
- Adapt the administrative framework (simplification of project management procedures)
- Support major research drives (storage, photovoltaic technologies, transition from R&D to industrial application)
- Strengthen the industrial sector (encourage the emergence of new bodies and organisations, mobilise funds, establish quality standards)
- Make photovoltaic energy available to everybody (training programmes, links with home automation)
- Introduce a major photovoltaic component into the Mediterranean Solar Plan

As in previous years, France's regional councils have played an active role in providing support for photovoltaic installation projects through targeted invitations to tender which involve energy efficiency and solar power.

#### Incentive measures

A series of directives have been set at national level designed to implement the recommendations that emerged from the Grenelle of Environment.

A set of public-funded initiatives are in place for structuring and supporting market expansion. These initiatives include a feed-in tariff, with special focus given to Building Integrated Photovoltaics, together with various tax schemes to help both individuals and companies.

Contracts for supplying electricity have been drawn up for a period of 20 years between each provider and a distribution company (ERDF in most cases). In accordance with the articles of the financial law which was passed in December 2008, proceeds from the sale of photovoltaic-generated electricity are (as of 2009) exempt from income tax, when the nominal power of the photovoltaic system does not exceed 3 kW.

Table 2 shows the feed-in tariffs applied in 2009

Tariff EUR/kWh	Mainland France	Overseas territories and Corsica
Basic tariff	0,32823 0,43764	
Building integrated photovoltaics	C	,60176

In September 2009, the government confirmed its intention to bring in an intermediary tariff of 0,45 EUR per kWh for "simplified" installations integrated into professional buildings.

The aim of this special rate for building integrated photovoltaics is to create a national economic sector by promoting the integration of solar installations into the French landscape as harmoniously as possible.

The main problem is that this special tariff involves the delicate task of classifying the various types of equipment that might fall into this category.

In order to take advantage of these tariffs, many investors have started to build empty buildings that serve no purpose other than to produce solar energy (for examples buildings that are supposedly used for farming, shade-structures that overhang supermarket car parks, etc.)

Measures were therefore announced in late 2009 to reduce speculation in the production of photovoltaic electricity that could ultimately lead to higher electricity prices. At the request of the regulators, new pricing rules will be implemented starting in January 2010, together with rules for classifying the various projects which will be able to take advantage of these rates.

Other measures supplement this incentive scheme:

- An income tax credit of 50% of the total amount invested in supplies for the photovoltaic system, with an upper limit of 8 000 EUR per taxpayer (16 000 EUR for a couple);
- For off-grid systems, the ADEME-FACE contracts have been kept.

Additional aid is also available from Regional Councils for financing the installation of systems.

#### Outlook

Targets set by the Grenelle of Environment include 5 400 MW of photovoltaic installed capacity by 2020, capable of providing for 1% of the country's total electricity requirements. The year 2009 brought with it a number of solutions that have moved the country a great deal closer to meeting these goals.

Although - from an energy perspective - the contribution of solar power in the horizon 2020 still seems marginal, from a manufacturing perspective, the sector has the capacity to create numerous jobs all the way along the value chain, from the production of silicon to the installation of photovoltaic systems.

The year 2009 was marked by the wide-scale development of building integrated photovoltaic systems and it should be noted that many major industrial players from both the construction and energy sectors are establishing themselves as both components manufacturers and systems operators.

The way in which feed-in tariffs are structured has so far created the conditions within which one of the world's first building integrated photovoltaics markets can develop. This should result in the emergence of numerous small and medium-sized players, and in innovation being stimulated. 2010 looks to be a year in which the rules - which have fostered the sector's development up until now - are refocused.

## 2 Implementation of photovoltaic systems

### 2.1 Applications

During the course of 2009, 220 MW were installed in mainland France and a further 30 MW across its overseas territories, making for a total of 250 MW. Figure 1 shows how installed power has grown since 2003 and Figure 2 shows how total installed photovoltaic capacity has grown during the same period.

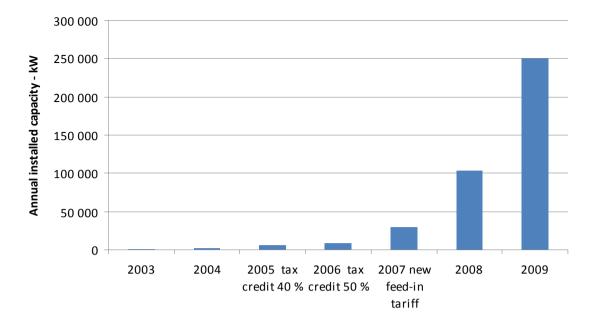


Figure 1 : Photovoltaic power installed annually in France<sup>1</sup> (2003 - 2009)

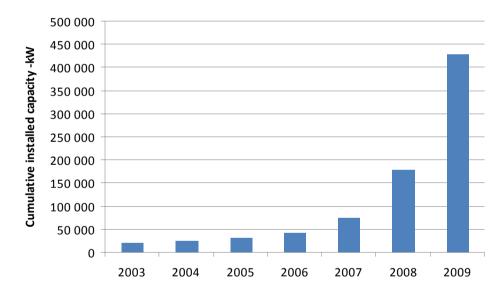


Figure 2 : Growth of the cumulative installed capacity (2003 - 2009)

The "off-grid connected" type applications - which accounted for 50% of the market in 2004 and which contributed greatly to study expertise and national engineering - now only account for a very small percentage.

Figure 4 shows the typologies of the systems installed every year since 2003 and illustrates the changes (off-grid versus grid-connected and centralized versus distributed systems).

<sup>&</sup>lt;sup>1</sup> includes Metropolitan France, Corsica and the four overseas departments: Guadeloupe, French Guiana, Martinique and Réunion

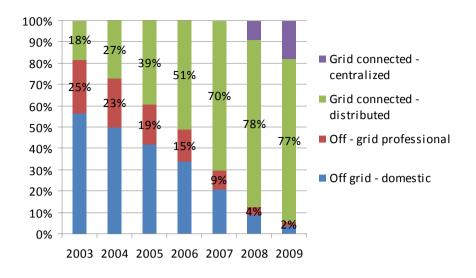


Figure 3 : Change in types of installations from 2003 to 2009

Figure 4 shows in more detail how the "non-grid connected" market has changed, with off-grid installations accounting for less than 1% of the total number of installations in 2009.

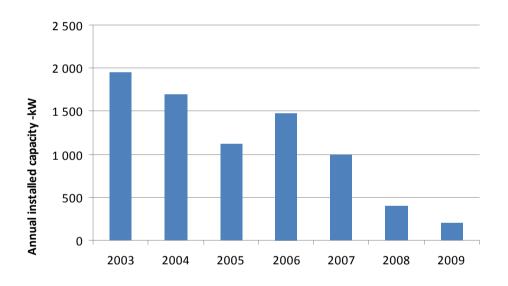


Figure 4 : Off-grid systems installed capacity between 2003 and 2009

In "grid-connected" applications, the residential market continues to drive the growth of photovoltaic electricity production in France, aided by financing schemes and very attractive tariffs. The most common applications are roof-mounted systems for individual houses (approximately 3 kW). This market is contributing to the spread of small installation companies throughout the country.

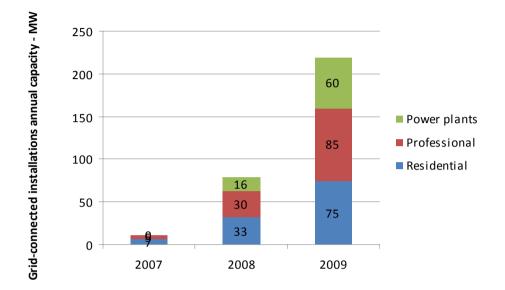
The market involving larger-sized roofs (several tens of kilowatts) for commercial or business buildings is growing. The roofs of large farm buildings are particularly sought after. These applications are increasing in number at the initiative of both individual people and professional associations.

Installations involving large roofs and ground-based power plants are increasing in number, with more time being required to bring them into service owing to the time it takes to put together the relevant administrative and financial files. This increase in the numbers of large-scale installations

is resulting in installation companies being set up that are more structured than the smaller companies.

As of the end of 2009, 17 power plants with capacities of over 500 kW were being managed by ERDF in mainland France.

Figure 5 illustrates how the distribution of various different installed applications has changed in mainland France.



### Figure 5 : Growth in installed capacity and applications (mainland France)

### 2.2 Grid - connected power

In 2009, the number of new installations being connected up to the grid increased dramatically, as the table below shows:

Table 3 : Increase i	n numbers of	installations	connected u	p to the g	grid
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	Power connected (MW)		Increase 2009/2008
	2008	2009	
Mainland France	37	152	311%
Overseas departments and Corsica	7	48	586%

For France's total photovoltaic installations connected up to the grid in 2009 (approximately 269 MW), including Corsica and its overseas departments, geographical distribution is as shown below: (cf. Figure 6):

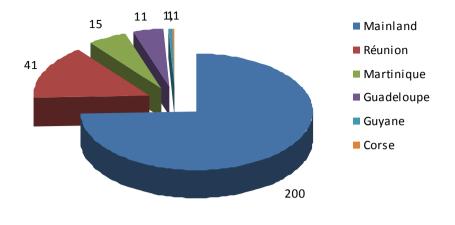


Figure 6 : Geographical distribution of France's grid-connected photovoltaic installations

The growth over the last three years in the numbers of installations connected up to the grid is differentiated, for mainland France/overseas territories and Corsica as shown in Figure 7.

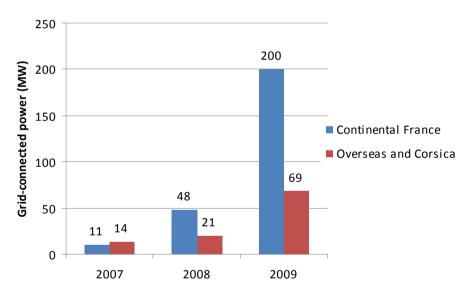


Figure 7 : Growth in grid-connected power for mainland France/overseas departments and Corsica

Figure 8 shows the geographical distribution of all of France's on-grid photovoltaic installations as of the end of 2009 across mainland France (approximately 200 MW)

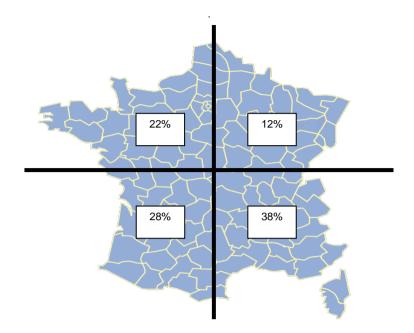
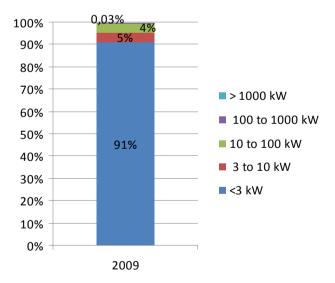


Figure 8 : Geographical distribution of grid-connected power

According to data provided by ERDF, the Distribution System Operator, 91% of all photovoltaic systems in service are installations less than 3 kW of power. These systems account for 47% of total grid-connected power. Installations between 10 and 250 kW account for 6% of all installations in service and 36% of total grid-connected power. Figure 9 summarises the distribution of the total number of grid-connected installations as of the end of 2009 based on their power.



### Figure 9 : Distribution of installations based on grid-connected power (December 2009)

Over a 12-month period, the total grid-connected photovoltaic installations generated approximately 280 GWh of electricity; (or, according to the SER, the equivalent annual electricity consumption of approximately 125,000 people - all electricity uses combined).

# 2.3 Highlights in the implementation of photovoltaics

### 2.3.1 General aspects

In addition to the enthusiasm that people are now showing for installing systems on their roofs, the year 2009 was marked by an increase in the number of high-capacity photovoltaic power plant projects getting underway (ground-based plants and large roof-mounted installations).

Limitations in the capacity of France's national operator (ERDF) to handle all requests to connect systems up to the national grid is currently affecting the high demand on the part of individuals and investors. As of 31 December 2009, 3 438 MW's worth of installations were awaiting connection, 2527 MW of which were in mainland France and 901 MW in Corsica and France's overseas departments. The operator connected up 59 MW's worth of installations during the last quarter.

A number of partnerships - designed to facilitate the development of photovoltaic power - have been established between financial organisations and companies in the energy sector.

Local and regional authorities are also providing a great deal of support in financing projects. This is in addition to the national tariff and fiscal incentive policies; different strategies have been adopted in different regions, as is shown in Table 9 on the following pages.

At the initiative of various associations and professional groups, a number of events have been organised for the general public designed to promote photovoltaic technology and the various ways of taking advantage of it.

### 2.3.2 Installation capacities

According to a survey of industry professionals, approximately 30,000 systems were installed in 2009 (all powers and uses combined).

There are 3 types of company capable of satisfying the market's requirements:

- Small companies with fewer than 10 staff
- More structured companies with more than 10 staff
- "Large companies" which often function as project developers and installers

For the residential market (which accounts for 91% of all systems installed in 2009), the various different categories into which installers fall (approximate 5300) is shown in Table 4 (*source: PWC study*).

Type of company	Small companies	More structured companies	Large companies
Services provided	Simple installation	Installation and services (administrative procedures, maintenance, etc.)	Installation and Services (financing solutions, insurance, etc.)
Number of installers (%)	80-85 %	15-20%	<<1%
Market share (no. of installations) (%)	approximately 20%	approximately 40 to 50%	approximately 30 to 40%

 Table 4 : Categories of "residential" system installers (kit types)

Source: PCW Study

According to a survey carried out by a private firm, the market was divided up among "large-scale" developers/installers in 2009 as follows (cf. Table 5)

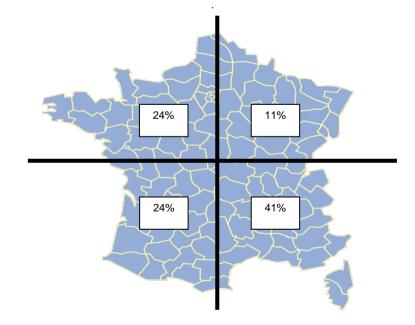
	Market			
Positioning	Residential	Professional	Ground-based plants	
General companies	EDF ENR, Sola	ire Direct, Poweo, Juwi, S	échilienne Sidec	
Companies specialised in high-power installations		Tenesol, E-on		
Companies specialised in roof-mounted installations	Evasol, Sunnco			
Companies specialised in residential installations	Calea, Soleil en fête			
Companies specialised		Clartene, Sun-R		
in professional installations		Sur	nvie	

### Table 5 : Positioning of "large" installation companies

Source: PCW Study

The total installed volume has grown as installation companies have arrived on the market. These companies have come from various different backgrounds, having diversified from their original business activity (electricians, roofers, etc.), attracted by the promising outlook of the photovoltaic market.

Figure 10 shows the geographical distribution of these installers throughout mainland France.



**Figure 10 : geographical distribution of installation companies in 2009** Source: Quali PV using a base of 3500 installation companies that were awarded certification in mid-2009

As was the case in 2008, 50% of these companies are concentrated across 4 regions: Rhône Alpes, Provence Alpes Côte d'Azur, Languedoc Roussillon and Pays de la Loire.

The regions which have been experiencing the highest rate of growth in the numbers of installers are those which enjoy "moderate" amounts of sunshine: leading them are Limousin, Champagne Ardennes and Brittany.

growth rate of numbers of ins	regions concerned	
minimum recorded rate	32%	Nord-Pas de Calais
average rate	63%	All regions combined
maximum recorded rate	240%	Limousin

#### Table 6 : growth in the numbers of installers across France's regions (2009 / 2008)

Source: Solar tools + analysis

### 2.4 Research and Development

#### 2.4.1 Public partners

The distribution of tasks between the ADEME and the ANR has resulted in the ANR handling upstream research and development projects prior to their industrialisation and entrusting the ADEME with providing support for industrial and technological developments aimed at marketing new commercial products.

The ADEME's strategy for supporting the development of the French market is structured around six different areas:

- Encourage the design of photovoltaic building materials as part of the PREBAT programme (research and design programme set up by the 2004 Climate Plan designed to develop synergies between the various projects being carried out as part of programmes such as Bâtiment 2010, Foundation for research into energy in the construction industry, European technological platform, 6th and 7th Framework Programme on Research and Development);
- Be involved in high-profile model financing operations, such as operations that are grouped together with high added architectural and educational value;
- Develop a method for factoring in photovoltaic power into savings in the construction industry;
- Strengthen quality and installation performance control;
- Closely monitor the way in which photovoltaic power is integrated into changes in thermal regulations;
- Study the implementation of financial tools specifically designed to accelerate market growth (low-interest loans, bridging loans, etc.).

The agency operates at several levels in its mode of action:

- Co-operation between funding partners;
- Training and dissemination of information;
- International activities.

In 2008, the ANR launched a new three-year research programme. The programme - known as HABISOL - merges research being carried out in construction and in photovoltaics to highlight the importance of integrating photovoltaic systems into buildings (see paragraph 2.4.2)

Alongside the ANR's activities, a major industrial project caught the attention of the public authorities in 2008. The Solar Nano Crystal R&D programme (2008-2012). OSEO and ADEME have pooled their funding in order to help get this ambitious project underway.

The ADEME is now less involved in providing financial support for opening up new markets, since favourable fiscal and financial measures have been put in place. These include the 50% tax credit on photovoltaic equipment and preferential feed-in tariffs (see below).

ADEME is still involved in providing training for project initiators (the PHOTON and PHOTON RESEAU training programmes), but in order to cope with growing demand, a number of other initiatives are now getting underway in professional training centres and at the National Institute of Solar Energy (INES). For example, in October, TRANSENERGIE inaugurated QUALIPHOTON®, its 220 m<sup>2</sup> educational and photovoltaic solar demonstration platform. It is equipped with the main photovoltaic components available on the market and showcases a number of different technologies: sc-Si, mc-Si, a-Si, CIS, CdTe. The facility will provide building owners, opinion leaders, architects, electrician-installers and roofers with training.

France's regional councils are also playing an active role in providing support for photovoltaic installation projects through targeted invitations to tender which involve energy efficiency and solar power. Competitivity clusters - regional initiative clusters bringing together manufacturing companies and public organisations - are also involved in research activities.

### 2.4.2 Technological research and development

Three complementary approaches have been developed within the context of the HABISOL R&D programme financed by the ANR over the period 2008-2010:

- A method for managing energy in the residential sector;
- Energy efficiency and increased use of renewable energies in buildings;
- Increased use of photovoltaic systems so that they eventually become standard in buildings.

14 new R&D projects were selected in 2009, in addition to the 10 projects that were selected in 2008.

Among these projects, the ones which involve photovoltaic installations deal with the following subjects:

- Adaptation of the back molybdenum contact and interfaces for solar cells using CIS junction/alternative buffer films
- Cells with contacts moved to the back face made based on ultra-thin silicon ribbon
- Innovative materials for photovoltaic solar cell electrodes
- Coloured photovoltaic modules for better architectural integration
- Multiplication of photons for improved output of photovoltaic cells
- Silicon heterojunctions for advanced cells with back contacts
- Crystalline silicon formed by laser crystallisation on metallic substrate for solar cells

The Solar Nano Crystal R&D project, financed by the OSEO and the ADEME, involves setting up a pilot manufacturing unit (Lab-Fab) for crystalline silicon photovoltaic cells. This pilot will test technical innovations that have emerged from public research laboratories. The overall objective is to reduce production costs, increase photovoltaic conversion efficiency and reduce the environmental impacts of the production processes. Work is being carried out in the following areas:

- Directly producing solar photovoltaic grade silicon;
- Significantly increasing the conversion efficiency of cells and modules;
- Directly using research results in a pilot cell production unit.

The project is being co-ordinated by the PV-ALLIANCE consortium (Photowatt, EDF EN and CEA-Innovation) in conjunction with a number of companies that are specialised in the production of silicon, such as EMIX, PHOTOSIL and APOLLON SOLAR, together with the National Institute of Solar Energy.

Another major R&D project is POLYSIL, financed by the ADEME, the Rhône Alpes region and a number of local authorities. It was launched in December 2009. The aim of this project, which has

been allocated an R&D budget of 15 MEUR, is to design a new generation of amorphous silicon modules, using technologies developed in research laboratories. SOLSIA is a young start-up company which coordinates the work schedule implemented by the laboratories in conjunction with companies.

The National Institute of Solar Energy (INES) brings together researchers from the CEA, the CNRS, the University of Savoie and the CSTB (staff of approximately 200 people which is set to increase). Its activity is spread across three different departments: INES - Education (information and education), INES - RDI (public/private research) and INES - Demonstration (technological pilots). Research being carried out into photovoltaics include the development of new industrial cell manufacturing processes, improvements in organic cell efficiency, the use of nanotechnologies, methods for modules characterization, electrochemical storage systems, energy management and system performance evaluation.

The activities of the Institute for Research and Development of Photovoltaic Energy (IRDEP) are mainly focused on thin-film technologies and high efficiency cell concepts, with particular focus on CIGS. The team is made up of 40 or so people, including researchers from the CNRS, EDF and the University of Paris.

Other public R&D initiatives are being led within institutes such as the INESS (Strasbourg), INL (Lyon) and IM2NP (Marseille).

Also worthy of note is the work being carried out by APOLLON SOLAR in developing a new type of module which does not require cell encapsulation, making it possible to produce simplified contacts (NICE project).

### 2.4.3 Others

Total, GDF Suez and Photovoltech have joined an R&D programme, the IIAP (Industrial Affiliation Programme), initiated by IMEC, an independent research institute specialised in nanoelectronics and nanotechnology. The programme seeks to significantly reduce the amount of silicon used while at the same time increasing cell efficiency, the aim being to substantially reduce costs in the solar sector.

Source: www.bulletins-électroniques.com

### 2.4.4 National conferences and events

A number of major events were held during the year designed to promote electricity production using photovoltaics.

The second Solar Event (26-28 June) was held in Savoie close to the facilities of the INES. Open to the general public as well as industry professionals, it was visited by nearly 15 000 people. Several themes were examined as a means of promoting photovoltaics: housing, professions, vehicles, boats, innovations, North/South initiatives.

From 25 to 26 June, the SIREME - the International Renewable Energies and Energy Management Show - was held, attracting some 30 000 visitors.

ENERGAIA, the renewable energies exhibition, was held from December 9 to 12 in Montpellier, and attracted 30 000 visitors, both professionals and members of the general public. This international event brought together some 400 exhibitors and offered visitors a broad programme of conferences, colloquiums, job forums and business meetings, as well as a conference for people seeking to invest in renewable energies, "green" housing and energy management.

Events were also held at the initiative of or for political decision-makers.

A conference was held by ENERPLAN (professional solar energy association) with the support of the ADEME aimed at mayors in France. Its aim was to raise people's awareness of local solar energy-related issues and the outlook for the future, within the context of a local energy and sustainable development policy (14 May).

An energy task force answering to the Senate, tasked with analysing energy policy issues in France, held a colloquium in June entitled: "23% of our energy to be derived from renewable energy sources by 2020: feasible target or utopian dream?" The experiences of various bodies and organisations involved in the sector (major groups invested in renewable energies, professional trade associations, elected representatives, consumers) gave an optimistic answer to this question, reasserting the need to make sustainable choices with regard to the support measures being implemented, both for consumers and for bodies involved in the technical aspect of the issue (R&D, designers, manufacturers, installers).

The number of associations involved in the renewable energy sector (CLER, ENERPLAN) once again held open days. These served as opportunities for thousands of members of the general public to visit photovoltaic installations and meet industry professionals.

The public's enthusiasm is genuine: they are interested in opportunities to find out more about photovoltaics and are seduced by the various regional and national incentive measures that have been put in place.

### 2.4.5 Competitivity clusters

Three of the 66 competitivity clusters set up in 2005/2006 are involved in projects related to photovoltaics:

- Tenerrdis in the Rhônes-Alpes region
- Derbi (Development of renewable energies in construction and industry) in the Languedoc-Roussillon region
- Capenergie in the Provence-Alpes-Côte d'Azur region

Each cluster receives funding from the OSEO, ANR and ADEME, as well as local authorities, depending on the interest in the projects they are working on.

### 2.4.6 PV Alliance Lab-Fab

PV Alliance is a joint subsidiary set up by EDF ENR, Photowatt International and the CEA. Its aim is to first develop and then produce high efficiency cells. PV Alliance will operate a pilot unit (25 MW) for approving and validating, on equipment which is representative of the industry, and using significant quantities, various technological innovations that have emerged from laboratories, including the INES.

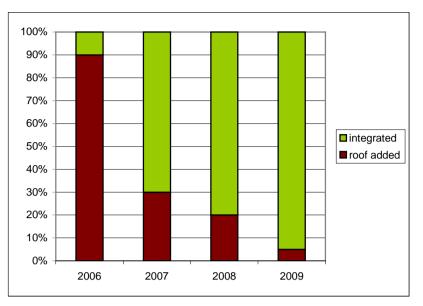
The first products were initially scheduled to come off this prototype assembly line - known as Lab-Fab - in autumn 2009. This has now been changed to mid-2010.

In order to meet its goals, PV Alliance has set itself up as partner and chief coordinator of a five-year research programme: Solar Nano Crystal. This project is receiving funding from both local authorities and the State, and involves 7 partners. It will hopefully result in sites being built that will produce two types of cell: high efficiency silicon cells made from purified metallurgical grade silicon, and very high efficiency cells using nanotechnologies.

### 2.5 Stimulating the market

Since 2006, the growth of the French market has been marked by increase in feed-in tariff of photovoltaic electricity, a tariff that was first introduced in 2002. It was the notion of "purchasing tariff" that suddenly established France among the world's ten largest photovoltaic markets. An incentive measure, strengthened by a tax credit, that serves as an additional tool for stimulating investment from private individuals. These incentives have a number of positive effects: strong market growth

and an offering that is more geared towards building integrated photovoltaics as illustrated by Figure 11



### Figure 11 : Change in the way "small-scale" systems (less than 36 kW) are mounted

### • National activities

For the photovoltaic sector, the government confirmed a feed-in tariff of electricity for 2009, as shown below in Table 7.

Tariff EUR/kWh	Mainland France	Overseas territories and Corsica	
Basic tariff	0,32823 0,43764		
Building integrated photovoltaics	0,60176		

#### Table 7 : Electrical energy feed-in tariffs in 2009 (EUR/kWh)

Source: EDF-Purchase Obligation

An intermediary tariff of 0,45/kWh has been brought in for so-called "simplified" installations integrated into the roof terraces of professional buildings, for example.

The government has confirmed that the pricing scheme will remain unchanged until 2012 - which should facilitate the growth of the industry in France.

In accordance with the articles of the financial law which was passed in December 2008, proceeds from the sale of photovoltaic-generated electricity are now exempt from income tax, provided the nominal power of the photovoltaic modules does not exceed 3 kW.

The government has also issued a series of invitations to tender for the construction of photovoltaic electricity generating plants in each region. The aim is to have at least one in each region by 2011.

In mainland France, grid connection requests for photovoltaic systems belonging to private individuals have increased considerably (around 3 000 requests per day across the whole country). Measures have been put in place to speed up handling of these requests, with the number of administrative procedures being reduced to two instead of five.

The following administrative obligations (cf. Table 1) have been introduced for constructions that produce electricity from solar energy (law of 19 November 2009).

			Procedure		
System specifications	No procedure	Prior declaration	Building permit	Impact study	Public enquiry
	1	Outside protecte	ed sector		I
P< 3 kW + H<=1.80 m	Х				
	•	Within protecte	d sector		• 
P< 3 kW + H<=1.80 m		Х			
	•	All sector	ſS		
P< 3 kW + H>1.80 m					
Or		Х			
3 kW < P< 250 kW					
P>250 kW			Х	Х	Х

### Table 8 : Necessary procedures to be followed for installing systems

P: power ; H: height

### • Regional and local activities

As the ENERPLAN association observes, France's regions and local authorities are also playing an important role in the growth of this market. Indeed, through being geographically close to the areas in which systems are being installed, they are in a position to know what types of activities and fundings are genuinely effective. They also benefit from growth in the sector: it contributes to the local industrial activity, there are financial incentives and the concept of eco-citizenship is enhanced.

France's regions and many other regional authorities (joint municipal authorities, communes) have been involved in funding since 2006. This funding can come in a number of different forms, as is shown in the funding summary table based on an inventory drawn up by the ENERPLAN association (www.enerplan.asso.fr).

Aid is distinguished by:	examples
<ul> <li>The people or type of project that benefits from it</li> </ul>	specific projects, collectively-run installations, off-grid sites, on-grid electricity production
The context in which the funding request is handled	at the request of the beneficiary, on the basis of proposals only, on the basis of purchasing group initiatives
The parameters used to define the total amount funded	installation cost, labour cost, installed W cost, percentage of installation cost, percentage of installation labour, estimated energy produced per year, estimated energy produced in the first year
The conditions under which funding is allocated	main residence, integration to the building,
The information used to specify any funding ceiling	resource conditions, investment total, generating capacity, total per W
Ranges of amounts	<ul> <li>example for a private individual, depending on type of funding, depending on region:</li> <li>700 EUR-1 000 EUR on the total cost of investment</li> <li>300-1 300 EUR on the installation labour</li> <li>10% to 30% of the cost of installation</li> <li>1 EUR/W to 2 EUR/W</li> <li>0,1 EUR/kWh/year to 0,2 EUR/kWh/year</li> </ul>

# Table 9 : summary of various forms of regional and local aid available for funding<br/>photovoltaic systems

# 3 The manufacturing sector

The set of business activities that together make up the crystalline photovoltaic value chain are continuing to establish themselves.

Table 10 shows how the various activities carried out by French bodies and organisations involved in the sector are distributed (with the involvement of some spanning several stages).

Two sections can be distinguished in the photovoltaic sector:

- An "upstream" section: from the production of photovoltaic materials to the production of the photovoltaic module
- A "downstream" section: this involves the integration (engineering, manufacturing and installation) of the modules into the systems, the integration of the systems into the field, as well as their operation

Value chain of the photovoltaic sector							
"Upstream" section of the sector			"Downstream" section of the sector				
Production of ingots	Production of wafers	Production of cells	Production of modules (mc-Si and a- Si)	Production of other components (BOS)	Engineering and project development	Installation	Operation
Number of companies involved in the various different stages of the value chain							
		1		~10	~50	~5000	> 20
1	1		9				

# Table 10 : The value chain of the French crystalline photovoltaic sector in 2009 Value chain of the photovoltaic sector

## 3.1 Silicon production

The SILPRO solar grade silicon production project which was launched in 2007 has now been stopped.

FERRO PEM – INVENSIL (a metallurgical silicon production company), APOLLON SOLAR and CYBERSTAR are partnering under the PHOTOSIL project to develop a new silicon production chain for the photovoltaic industry that involves significantly lower production costs than those incurred by established processes. A prototype pilot (200-tonne annual capacity) has been built in Bourget du Lac, near the facilities of the INES (National Institute for Solar Energy). The process consists in eliminating a number of impurities, including boron, using a plasma torch developed by the CNRS. The aim is to be able to market solar grade silicon at around 25 EUR/kg.

### 3.2 Production of ingots and wafers

Table 11 lists the industrial stakeholders involved in ingot production, together with information about the nature of their production.

Producers	Technology	Production	Installed capacity	Product recipients
PHOTOWATT	mc-Si ingots	600 tonnes	1 000 tonnes	own needs for producing wafers and then cells
EMIX	mc-Si ingots	80 tonnes	360 tonnes	France and export
PHOTOWATT	mc-Si wafers	equivalent to 70 MW	equivalent to 70 MW	own needs

Table 11 : Ingot and wafer production and production capacity - France 2009

mc-Si: multicrystalline silicon

### 3.2.1 Photowatt International

Photowatt International S.A.S. is a subsidiary of the Canadian group ATS. The company, based in Bourgoin-Jallieu, near Lyon, currently employs 750 people. Photowatt's business, launched in 1978, incorporates every step of the photovoltaic supply chain, from the production of silicon in ingot moulds to the design of systems and the supply of turnkey solutions (on-grid systems, residential roofs, industrial and farm buildings, turnkey solar power plants). Photowatt uses all of the ingots produced in order to manufacture the equivalent of 70 MW of wafers.

Photowatt is a partner and shareholder in the PV Alliance consortium, which is made up of EDF ENR and the CEA, and was set up to carry out research and development of new photovoltaic cells.

### 3.2.2 Emix

EMIX, based in St. Maurice near La Souterraine (Creuse), is a company which employs 30 people and is involved in producing and selling silicon ingots.

The crystallisation process - which EMIX has used since 2004 - involves silicon being continuously pulled from a cold electromagnetic crucible. It can be used to create silicon ingots with a multicrystalline structure. Its continuous nature, high productivity and easy, highly automated operation are what distinguish it from traditional processes. The main advantages of this technology are the following: homogenous quality of ingots, material output up to 50 wafers/kg, process suitable for use with UMG silicon, 100 times lower concentration of metallic impurities, no deterioration of the

crucible, lower consumable costs, no silicon pollution, low energy consumption (10 kW/h/kg), process that is not harmful to the environment (no liquid or gaseous discharge).

Recent investments have made it possible to increase annual production capacity to 360 tonnes per year - which corresponds to approximately 60 MW per year.

Various R&D projects involve initiatives to purify metallurgical silicon (industrial pilots), increase productivity (50 kg/h) and increase ingot sections (400 mm x 400 mm)

### 3.3 Production of cells and modules

Table 12 lists the main industrial cell and module stakeholders, together with information about their production capacities.

### Table 12 : Modules production capacity - main stakeholders - France 2009

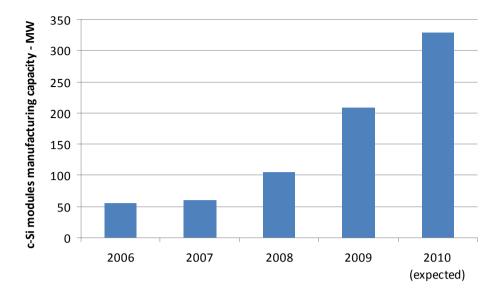
Crystalline technology

	Year			
Stakeholder	2009 MW	MW forecasts for 2010		
Photowatt	70	70		
Tenesol (*)	55	55		
PV Alliance	-	25		
Fonroche Energie	25	60		
Auversun	22	22		
France Watts	20	20		
SIllia Energie	20	20		
Sunland 21	8	8		
Voltec solar	-	50		
Total capacity for France	~210	~330		

### Other technologies

	Year		
Stakeholder	2009 MW	MW forecasts for 2010-2011	Future
Free energy (a-Si)	1,2		
First Solar (CdTe)		100	
Nexcis (CIGS)			50 (in 2014)

The strong growth in manufacturing capacity for module production is clearly shown in Figure **12** below.



### Figure 12 : Growth in production capacity for c-Si modules in France (2006-2009)

### 3.3.1 Photowatt International

Using the silicon produced in its own plant, PHOTOWATT manufactures cells followed by modules (70 MW of annual capacity).

As part of the PV Alliance's Lab-Fab project, capacity and cell production should increase by 25 MW.

As part of the policy to develop the use of photovoltaics in France, part of the production is devoted to building integrated photovoltaics (products designed to be integrated into rooftops/facades), under development partnerships with other companies (integration of photovoltaic into IMERYS tiles, use of SOLRIF frames).

### 3.3.2 Tenesol

TENESOL (formerly known as Total-Energie) is a subsidiary of the TOTAL and EDF groups. TENESOL SA, which employs 120 people in France, is one of the companies that makes up the TENESOL group. With nearly 1 000 employees, TENESOL is well-established in France's overseas territories, as well as throughout the rest of Europe, Africa, the Middle East and America.

In Toulouse, production capacity will be increased to 85 MW with the creation of a fourth production line. This line will be equipped with a Tabber-Stringer (for serial connection of the photovoltaic cells) and a laminator (to combine the glass, the cells mounted in series and encapsulated in an Ethyl Vinyl Acetate film, and the isolating sheet on the back). The Tenesol Group intends to develop the module manufacturing capacity (Toulouse and Le Cap Facilities) up to 170 MW on the 2010-2011 period.

### 3.3.3 Fonroche Energie

FONROCHE Energie is a partnership created by FONROCHE and the Spanish company PEVAFERSA. It designs, manufactures and provides turnkey installation of photovoltaic systems that it produces at its Roquefort factory (Lot et Garonne). Its module manufacturing facility has an annual capacity of 25 MW.

### 3.3.4 Auversun

AUVERSUN manufactures single crystalline and multicrystalline silicon modules at its Clermont Ferrand site using European wafers (annual production capacity of 22 MW). From its production site, AUVERSUN designs and manufactures customised solutions (kits for individuals, farming and industrial buildings, shade-structures that overhang car parks, free-standing columns).

### 3.3.5 France Watts

France WATTS designs and manufactures modules at its Barentin site (Seine Maritime) (20 MW). Its products are intended for integration into roof structures in particular. They are distributed in kit form, comprising inverters, boxes, cables and connectors.

### 3.3.6 Sillia Energie

SILLIA (which started off as a company specialised in manufacturing printed circuits) began manufacturing multicrystalline silicon modules in June 2009 at its site in Lannion (Côte d'Armor) via SILLIA Energie. These modules are well suited for use in building integrated photovoltaics (20 MW)

### 3.3.7 Sunland 21

Sunland 21 designs multifunctional building enclosure systems in the form of large-format selfsupporting metallic panels. High efficiency cells are superimposed onto these using a flexible, automated process. The annual capacity of its Anse site (near Lyon) is 8 MW. Investment projects are being planned that would increase the production capacity to 35 MW.

### 3.3.8 Free Energy

The FREE ENERGY production facility is near Lens (Pas de Calais). Created in 1985, this facility employs 15 people and manufactures and sells thin-film photovoltaic modules. Initially geared towards designing products intended for electrifying off-grid sites, its activity has expanded to include the development of on-grid systems, and more particularly building integrated photovoltaics (its 2008 turnover was approximately 10% higher than that of the previous year).

### 3.3.9 New stakeholders and industrial projects underway

In 2008, EDF ENR and Imerys set up a joint company (Captelia) specialised in the manufacturing of building integrated photovoltaic systems (an R&D and production site set up in the Rhône Alpes region). Imerys-Toiture is France's number one producer of clay tiles. Its product catalogue includes photovoltaic tiles (made from mc-Si cells that were developed with Photowatt in 2002 as part of the European "PV Starlet" project), which can be used on roofs instead of traditional tiles.

A start-up (SOLARFORCE) has developed a process that makes it possible to reduce the amount of silicon used for the manufacture of cells by 75% (using ribbon technology).

SOLSIA was created in 2008 to design, produce, and sell modules specifically built for roof-mounted installations and ground-based power plants (1.4 sq.m modules). The technology was developed by SOLEMS (thin-film silicon). The goal is to start producing photovoltaic modules at a pilot site in 2011 and then in a 50 to 100 MW Lab Fab by 2012.

VOLTEC SOLAR was set up in November 2009 and is based in Alsace. It is scheduled to start production in the first quarter of 2010, eventually reaching an annual production capacity of 100 MW of single crystalline and multicrystalline silicon modules (4 successive stages). This will establish it as France's leading manufacturer of modules.

A 10-person start-up (S'TILE) based in Poitiers is working on a new silicon substrate manufacturing concept which involves sintering silicon powder. The advantage of the technology involved is that it does away with the need to merge the ingot and cut the wafers.

TOTAL and GDF-SUEZ are already involved in solar power through Photovoltech, their joint subsidiary which manufactures crystalline silicon photovoltaic cells in Belgium. They have now announced their intention to set up a silicon wafer manufacturing unit at the Vernejoul site in Moselle.

NEXCIS has been operational since July 2009 and uses a new low-cost thin-film (CIGS) photovoltaic cell production process based on breakthrough technology. Unlike "conventional" technology which involves vacuum coevaporating copper, gallium and indium with selenium under pressure, Nexcis has developed a process which can be performed at atmospheric pressure, meaning time savings and cost reductions. The R&D phase was launched in April 2009, and should conclude in April 2011. NEXCIS is then planning to build a pilot manufacturing unit over the next two years: Nexfab 1, a full-

scale plant designed to validate the project's relevance and viability.before launching Nexfab 2 in around 2013, a production unit capable of producing 100 MW,

EASY SOLAR, a design firm and turnkey systems installer, is developing a module production line. ENERGIZ SA has acquired the SOLARSTYL licenses (from ARCELOR MITTAL) and NICE TECHNOLOGY licenses (from APOLLON SOLAR) for the industrialisation of these new processes in 2010. The first module production unit should have an annual capacity of 20 MW, capable of being stepped up to 40 MW.

FIRST SOLAR is going to build a thin-film (CdTe) photovoltaic module factory in Blanquefort (Gironde). FIRST SOLAR will build and operate this factory, which will have an annual capacity of 100 MW. It will be partly funded by EDF ENR, which will get all the total production at the site over the first 10 years of its operation in order to develop photovoltaic installations throughout France.

POUJOULAT, which is specialised in manufacturing chimney and flue systems, as well as metallic roof outlets for chimneys, has production sites throughout France's Poitou Charentes and Rhône Alpes regions. It has developed a roof-integrated photovoltaic system (low and medium power systems).

SOLAIRE DIRECT was set up in October 2006 and is present along the photovoltaic value chain from module production (SOLAIRE DIRECT TECHNOLOGIES) right up to operation of decentralised electricity production systems. SOLAIRE DIRECT TECHNOLOGIES has already set up one module production factory in South Africa, and is now establishing a presence in mainland France (in the Poitou Charentes and PACA regions), with two 36 MW units in development.

SOLAIRE France SARL has been supplying photovoltaic tiles since 2007. The company is about to start sharing production with SAINT GOBAIN SOLAR in the south of France.

SYSTOVI SAS was set up in 2008 and produces modules and integration systems at its St Herblain site (Loire Atlantique). Its new manufacturing site opened in October 2009, and so annual production capacity should reach 40 MW over the next two years.

Saint-Gobain is actively pursuing a growth policy in the solar energy sector, and has taken over Shell's stake in AVANCIS, a jointly-owned company. It produces CIS technology modules at its 20 MW capacity factory in Torgau (Germany). Saint-Gobain Glass is also seeking to develop a new type of layered glass for photovoltaic cells in the pyrolysis line of its Aniche factory (Aisne).

A number of initiatives are also underway in the field of photovoltaic material processing through the VOLTAREC project, which aims to develop a comprehensive system for recycling solar panels.

### 3.4 Components and systems production

### 3.4.1 Components

TENESOL, as part of its systems manufacturing activity, has inaugurated an inverter production line (1 to 5 kW) and developed monitoring systems.

A facility belonging to the company PRYSMIAM has been set up in Pont de Cheruy (Isère) for producing and selling special connectors for photovoltaic installations.

The group SCHNEIDER ELECTRIC is continuing to expand in the industry and has set up a number of special production sites for monitoring systems, concrete connection stations specially designed for photovoltaics, inverters, cabinets and junction boxes.

Groups such as FERRAZ SHAWNUT (Carbone Lorraine), SOCOMEC, AINELEC and COMECA (low-voltage equipment) are producing components for PV systems at their French sites.

### 3.4.2 System design and construction

12 MW of systems were installed in 2009 by APEX BP SOLAR (+ 33% compared with 2008) ; 5 MW of them were dedicated to residential systems. This historical PV French stakeholder since 1991 is

presently developing activities in the BIPV market through a partnership with nearly 40 "Quali PV" labelled installers, and for residential applications, standards PV kits have been developed. Turn key systems are proposed to industrial customers, from financing service to installation and operation of the systems. In addition, APEX BP SOLAR maintains activities in rural electrification programmes implemented by industrial groups or NGOs.

Nearly 50 MW of systems were installed by TENESOL in 2009 (+66% compared with 2008). TENESOL develops, industrialises, produces and sells turnkey solar power systems for connection to the grid to manufacturing companies, farmers, local authorities and off-grid sites (established market). The Group is planning to pursue its growth in 2010, setting up a dedicated direct sales subsidiary for private individuals,.

PHOTON TECHNOLOGIES, a subsidiary of EDF ENR (EDF Energies Nouvelles Réparties) was created in 2006 and succeeded in quadrupling its 2007 turnover in 2008. 6 MW of systems were installed in mainland France. PHOTON TECHNOLOGIES is seeking to establish a presence along the entire value chain.

Many other companies, including PHOTOWATT, CONERGY, SUNWATT, SOLARCOM, etc., have also established a presence on the market as either assemblers or providers of turnkey systems.

### 3.4.3 New products

The heavy tariff support for systems that use photovoltaic components integrated into buildings is encouraging industrial firms to develop them in order to meet the demand. Figure **11**shows the effect that tariff incentives are having on the increase in the numbers of "building integrated" installations.

In 2009, there were more than 80 products on the French market that were "eligible" to receive the building integration bonus (source: "solar systems"). These products both generate electricity and serve as a means of waterproofing the roof/building facade. They mainly include tiles and slates, modules integrating a waterproofness function, sheet metal (steel, zinc, aluminium, and fibre cement), flexible membranes and canopies.

Many French manufacturing companies have contributed to this line:

PHOTOWATT has developed and is marketing a photovoltaic tile, and is working in partnership with IMERYS. The CSTB (France's scientific and technical centre for the construction industry) has issued PHOTOWATT with technical evaluation certification for its Wattéa integration solution.

Other projects involving BARUSCH and FISCH in Alsace have led to the development of a photovoltaic tile that integrates a photovoltaic module into a tile-shaped rooftop panel (made of recycled polyethylene).

The SORA group (a manufacturer of composites) has also been producing a photovoltaic tile since June 2008.

URBASOLAR, a company specialised in the production of watertight photovoltaic membranes, has plans to set up a 20 MW production facility in France.

Two industrial facilities within the PHOTON POWER group have been in operation since 2006, producing solar plates and a system for integrating them into canopies.

The companies KAWNEER and APEX BP SOLAR have developed a photovoltaic solution that provides shade and meets weather protection requirements. APEX BP SOLAR and DUPONT DE NEMOURS (which specialises in building enclosures) are working together to develop a new roof-mounted integration product.

CLIPSOL, which has been specialising in solar power since 1979, is manufacturing complete generators that are mainly roof-integrated (with a capacity of 50 000 m<sup>2</sup>/year). Under the responsibility of CLIPS'HIOLLE, a subsidiary set up with HIOLLE Industries, CLIPSOL has developed an integration macrostructure installed as fields of pre-assembled 20 m<sup>2</sup> solar panels.

HELIOPTIM, a young company created in 2008, has developed integration solutions specifically for industrial and commercial buildings (roof terraces), as well as ground-based solar power plants.

TENESOL has established partnerships with innovative manufacturing companies in the building sector (Arcelor MITTAL for steel plates, ETERNIT for construction materials used in roofing and SMAC -for building enclosures- in order to develop special products that are specifically designed for integration into buildings).

### 3.4.4 Research firms, associations

Companies involved in consultancy, market research, training, technical research and project management have been set up to support the industry as it expands. Trade associations and unions such as ASDER, CLER, ENERPLAN and SER are very active in promoting photovoltaics, and are seeing to establish contacts with the market and the state authorities.

### 3.5 Industrial activity outside France

This section provides a few examples of activities being carried out by French manufacturing companies in the photovoltaic sector abroad:

### • Saint-Gobain and CIS

The SAINT GOBAIN group, which holds 20% of the world's photovoltaic glass market, is seeking to speed up expansion of AVANCIS which was inaugurated in mid-October 2008 in Torgau, near Leipzig (Germany), with SHELL (which is providing the patents). The photovoltaic module factory has an annual capacity of 20 MW. As well as the planned openings of new plants, SAINT GOBAIN is not ruling out acquiring other companies in order to establish a presence along the entire PV supply chain: from module distribution through to installation.

#### Total Photovoltech

In 2004, Photovoltech's Board of Directors approved the decision to increase the production capacity of photovoltaic cells from 13 MW to approximately 80 MW per year. Two new production lines were inaugurated in Tienen (Belgium) in 2007. In September 2008, Photovoltech (Total, Suez-Electrabel - Soltech and IMEC) confirmed that it would move forward with its plans to increase its capacity to 140 MW in 2009. The new factory should be ready in early 2010 for the commissioning of the first additional production lines. The facilities of this new building - together with those already in existence - should enable Photovoltech to reach a total annual production capacity of proximally 500 MW (*source: photovoltech*)

#### Carbone Lorraine

The photovoltaic sector has become a growth opportunity for the CARBONE LORRAINE group. In order to strengthen its position, CARBONE LORRAINE has taken over control of the Scottish company CALCARB, the world's second largest manufacturer of rigid graphite felt, used as insulation in very high temperature ovens, particularly ovens for producing solar silicon.

Source: Carbone Lorraine

#### • Air Liquide

Air Liquide provides all the gases which are essential in photovoltaic panel production: carrier gases, doping and special gases, nitrogen, hydrogen and silane. Since 2009, through the drawing up of several long-term contracts, Air Liquide has been the main supplier for the world's three largest photovoltaic production sites: in Thalheim (Germany), home to Europe's largest "Solar Valley", in the eastern region of China, where the group will be providing a turnkey solution for the supply of gas used in the production of thin-film solar cells and in the Philippines where Air Liquide has extended its partnership with SUNPOWER for the manufacture of high efficiency cells.

The group is now partnering the world's three largest manufacturers of crystalline silicon technology solar cells.

Source: Air Liquide

### 3.6 Component and system prices

Figure **13** shows the trend observed over the last 12 years in the price of modules on the French market. With an estimated 30% drop in prices during 2009 compared to 2008, module prices in France vary between 1,10 EUR/W and 1,30 EUR/W for components manufactured in China, and between 1,50 EUR/W and 2,00 EUR/W for components manufactured in Europe or Japan (for quantities of at least several tens of watts).

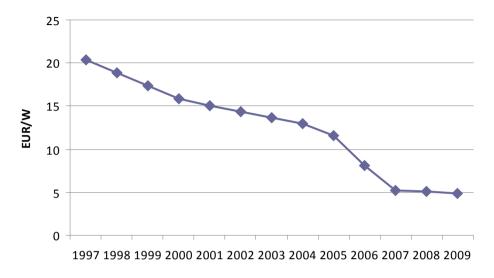


Figure 13 : Average sale prices of crystalline Si modules (excl. tax)

Little variation is noted for BOS (Balance of system) components.

Table 13 show turnkey market prices for various types of installation (EUR per W, not including tax).

Typical Application	Pri	ices EUR/W (excl.	ax)
	2007	2008	2009
Residential (< 3 kW)	7,7 to 8,4	7,5 to 8,3	5 to 5,5
Large manufacturing sector systems (< or = 500 kW)	6,5 to 7	5,5 to 6	3,5 to 4,5
Ground-based photovoltaic plants	unknown	unknown	2,5 to 3,5

 Table 13 : Turnkey prices for typical applications

The average costs quoted include all the accessories needed for a turnkey, on-grid photovoltaic system. However, the total cost for the provision and installation of systems offered by different companies can vary depending on the types of equipment used, the guarantees included and the difficulties encountered in installing equipment on the roof.

According to a study conducted with a number of installers *(www.outilssolaires.com)*, the average price excluding tax of a 2 kW turnkey system with roof-integrated modules is nearly 11% higher than that of a system involving photovoltaic modules that are simply "mounted" on the roof. The price difference is attributed to the accessories and additional labour that is required in order to ensure that the roof is waterproof.

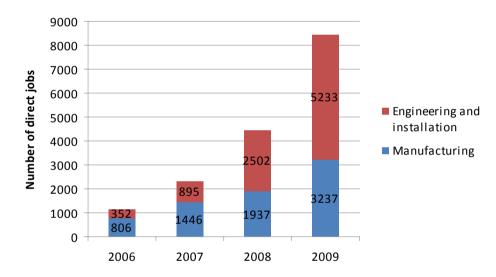
The cost of building integrated photovoltaics systems (equipment and installation) varies depending on the integration methods used, as shown below (cf. Table 14):

	Ground-based or "added" roof modules	"Simple" roof integration of modules	Integration into more sophisticated roof (canopies, photovoltaic tiles, etc.)
1 to 3 kW	5 - 5,5		> 9
>10 kW	4 - 5	6,5 - 8	< 13

 Table 14 : Impact of the module installation method used on the turnkey price of a typical low-power installation (EUR excl. tax/W).

## 3.7 Employment

According to a survey carried out by the ADEME (Markets and jobs, October 2009), there was a very significant increase in the number of direct jobs in the photovoltaic sector. Figure 14 illustrates the movements in the industry since 2006.



### Figure 14 : Increase in the number of direct jobs in the photovoltaic sector (productioninstallation) (2006-2009)

These findings confirm the various analyses carried out by the ADEME in its July 2008 study, which estimated that up to 13 400 jobs could be created in the photovoltaic industry by 2012.

### 3.8 Quality Policy - directives and standards

The installation of systems at both off-grid and on-grid sites must be in compliance with directives, practices, and recommendations issued by the UTE (technical electricity union), EDF and ADEME. The trade syndicate SER plays an important role in preparing these technical guides.

Heavily supported by the profession and government authorities, a number of quality insurance strategies have been implemented. The "QualiPV" label (www.qualit-enr.org/qualipv) was introduced in 2007 (it is a quality label on the labour performed by the workers installing the systems). For a company to be awarded a "QualiPV" label, it has to undertake to comply with 10 points of the QualiPV charter (drawn up by companies in the profession). To be part of this quality insurance strategy, the company has to provide evidence of its expertise, through generic "QualiPV" training modules delivered throughout the country.

Since 2009, QualiPV certification requires 3 days of training for the "electricity" module and 2 days for the "building" module.

As of the end of 2007, no installation company had embarked on the QualiPV label process. By the end of 2009, approximately 5 600 installation companies had been awarded the "QualiPV" label (2 500 by the end of 2008), with 80% of them employing less than 10 people. Audits have been launched to assess the quality of the installations carried out by these companies. The results of these audits will be known in 2010.

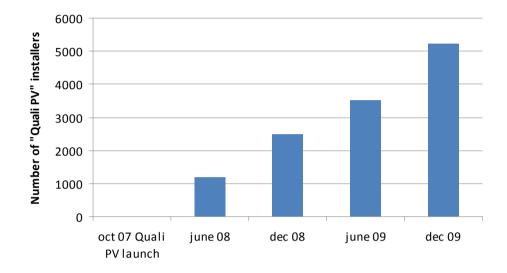


Figure 15 : Increase in the number of companies which abide by the QualiPV charter

In order to encourage use of photovoltaics in buildings, new procedures have been developed by the CSTB (France's scientific and technical centre for the construction industry) which is tasked with ensuring that new developments in the construction industry are in compliance with current regulations.

In France, the implementation of traditional building procedures is governed by standards referred to as DTUs (standardised technical documents). Compliance with these standards guarantees the quality of buildings, thus minimising the risk of accidents during construction. These standards also often serve as a reference basis that insurance companies can use to deal with any accidents in construction in accordance with the terms of cover provided by their basic contracts.

However, integration processes for photovoltaics are not yet considered traditional, and so do not fall within the scope covered by the DTU documents. The question therefore arises as to how to ensure that the process of building integrated photovoltaics keeps risks to a minimum and are properly covered by insurance companies.

The CSTB provides a number of voluntary initiatives that can help answer this question. www.cstb.fr. Among them is the "Pass Innovation", a voluntary scheme which provides companies, technical auditors and insurance companies with a preliminary technical assessment of a product or process in less time (3 months). It provides the guarantees that are required before a product or process can be put on the market, before the technical evaluation certification can be applied for (it serves as an optional step along the path to this certification). There are three stages involved in the Pass Innovation scheme. First, the procedure is defined; an analysis of its suitability for the purpose for which it was designed follows; a final report is then drawn up. This report ends with three possible outcomes:

- Green light: the risk is very limited and can be managed by recommendations for its implementation and/or supervision;
- Orange light: there is a "potential" risk: it is recommended that the product's or process suitability to be checked on a pilot project;

• Red light: the risk is not adequately managed and the techniques involved have not been properly developed as they stand.

10 "Pass Innovations" for photovoltaic procedures were issued in mid-December 2009.

At the request of a number of module manufacturers, the LNE and the CEA (with support from the ADEME) have decided to set up a photovoltaic module performance certification platform at the INES site. Certification is awarded in compliance with the quality criteria laid out by the NF EN 61215, NF EN 61646 and NF EN 61730 standards.

The ADEME is also continuing its involvement in shared-cost projects within the International Energy Agency, particularly in working groups 1, 2, 9, 10, 11 and 12. The International Electrotechnical Commission receives contributions from French teams supported by the ADEME, particularly for drawing up technical specifications for using renewable energy sources to provide rural communities with electricity.

# 4 Conclusion and outlook

The target set by the European Council requires that 20% of the final energy that we consume be derived from renewable energy sources by 2020, and the photovoltaic market is continuing to expand without the quality of the installations being compromised. The French market enjoyed very strong growth in 2009. The generating capacity installed in 2009 was eight times greater than that installed in 2007, and this growth looks set to continue. The feed-in tariff, the additional bonus granted to building integrated photovoltaics and the creation of the special "sustainable development" tax credit were all factors that fed this growth. These incentives have many positive effects:

- Market growth;
- The structuring of industrial and professional offerings, in both the production and the installation sectors;
- An increase in the number of technological innovations, of R&D initiatives for new products;
- The creation of qualified jobs,
- The introduction of systems to monitor the quality levels of installations carried out.

The creation of the photovoltaic power plants that was announced in 2008 is now underway. New bodies and organisations involved in electricity production are being set up.

The French industrial sector is growing rapidly, with the involvement of major French energies holders (EDF, Total, GDF-SUEZ, CEA, etc.). Significant government backing has been provided at national level (PV Alliance, Competitivity clusters, the Institute of Solar Energy), coordinated by extensive support from France's regional and local governing councils.

The crystalline silicon industrial sector is expanding. Thin-film photovoltaic industries are establishing a presence in France, extending existing research projects and partnerships established by French manufacturers. Joint initiatives carried out by the photovoltaic and construction industries are on the increase, both at research and manufacturing level, as growing emphasis is placed on building integrated photovoltaics.

France's aim is to play an important role in the technological revolution that is currently underway. The goal is to turn solar energy production into something that can compete with the market price of electricity by 2020.

# **Appendix: Working methods**

This report was drawn up without the contributions of a number of manufacturers, the majority of whom were not able to reply to the questionnaires that were sent to them. Companies are required to reply to numerous questionnaires - doubtless a factor behind their lack of enthusiasm for taking part in yet another study.

Details of the activities of manufacturers and the various research initiatives were collected throughout 2009 and the first quarter of 2010 from press releases issued by the companies in question, published studies, articles in journals and on the Internet and interviews with specialists in the field.

A great deal of quantitative information was collected from the solar energy branch of the SER -France's professional association of bodies involved in renewable energies - and from various professional associations (ENERPLAN, CLER, etc.), as well as quarterly reports drawn up by ERDF.

Note: ISO regulations were respected for referring to units of electrical power (W), although it is customary to use  $W_c$  in the field of photovoltaics.

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