

French know-how  
in the field of  
**renewable energies**





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**The term “renewable energy” denotes all energies derived from renewable non-fossil sources: wind, solar, geothermal, bioenergy, hydroelectric and marine energies.**

**They are used to produce electricity, heat and fuel. These energies are theoretically inexhaustible, and have a very low impact on the environment.**

## > Context

The development of renewable energies in France has undergone a major transformation with the implementation of the Grenelle Environment (environment round table). In this framework, France has set a target so that 23% of the total energy consumption in 2020 should be renewable energy.

In promoting these energies, France aims to respond to four major issues.

### 1. combating climate change

Greenhouse gas emissions linked to human activities and the exploitation of fossil fuels are leading to a rise in the temperature on earth. This phenomenon runs the risk of producing serious consequences, by threatening the climate, ecosystems and mankind.

Faced with these challenges, the international community has set the target of halving greenhouse gas emissions by 2050. France has pledged to quarter its greenhouse gas emissions. Its first target is to reduce emissions by 20% by 2020.

### 2. security of supply

France is highly dependent on the importation of fossil fuels, but wishes to diversify its energy supply. Renewable energies are a strategic alternative considerably reinforcing the security of supply.

### 3. protection of human health and the environment

The production and consumption of fossil fuels have a considerable impact on the environment, particularly on air quality and therefore human health, and also on the countryside and the ecosystem. By developing renewable energies, France also aims at reducing environmental pollution brought by fossil fuels.

### 4. development of “green” industrial sectors in France

The promotion of renewable energies is also an industrial and social issue. The development of these new technologies contributes to modernizing the industrial fabric and improving the competitiveness of companies. They are one of the strategic mainstays in the establishment of a green economy.

In France, general eco-activity production amounted to 62.5 billion euros in 2008. It generated a commercial surplus of around 2 billion euros, with exports achieving 6.9 billion euros.

Eco-activity employed 405,000 people in 2008, an increase of 2.9% compared to 2007. This growth is a result of the boom in renewable energies, which created over 50,000 jobs.

Many companies that specialize in renewable energies have set up in France in recent years. These companies manufacture equipment, fit and install equipment, and handle the sale of energy.

For developing and emerging countries, renewable energies offer interesting prospects. By targeting these energies in the first instance, it is possible to avoid the drawbacks of fossil fuels and immediately commit to the path of sustainable development.

Having considerable natural resources, many emerging countries can benefit from renewable energies.

France is using its know-how to implement international projects through private initiatives as well as with the support of dedicated public institutions, and aims at meeting the needs of partner countries in the field of renewable energy. These technology transfers help to protect the environment and combat climate change.

**Thanks to favourable public policies, France now has hundreds of companies specialized in the field of renewable energies.**

**A know-how which is being exported more and more all over the world.**

## > Wind is becoming established

On a global level, wind energy is now expanding at a rate of 30% a year. Abundant energy, good value, inexhaustible, non-polluting and with no impact on the climate, wind energy has many assets. The impacts of these installations on the environment (countryside, birds, bats, etc.) are better and more efficiently managed.

Wind energy also has a positive economic and social impact. It now represents a highly dynamic market of over 50 billion euros, employing several hundred thousands people around the world. In 2009, the installed capacity of wind energy throughout the world reached over 159 GW, representing around 2% of total electricity consumption.

France has over 3,000 wind turbines with an installed capacity of 4.7 GW. Wind energy alone will make it possible to achieve 25% of the objective fixed by the Grenelle Environnement. In 2020, the French fleet should include some 8,000 wind turbines with a total power of 25 GW. The potential already exists, with between around 400 and 500 wind turbines, which is 1,000 MW, commissioned every year in France. This is the equivalent of the power of 1.5 thermal plants or around 1 nuclear reactor.

### Mature technologies

Wind turbines are extremely reliable electricity production equipment, and have an availability factor of around 98% (percentage of time that wind power plant is ready to operate).

**Land wind turbines** are the primary form of wind energy, either in the form of a wind farm or in isolation. Thanks to technological advances, the power of wind turbines has multiplied by 10 between 1997 and 2007.

Today, a single 2 MW wind turbine provides electricity for 2,000 people, including heating. An average 12 MW wind farm prevents the emission of 8,000 tons of CO<sub>2</sub>.

**Offshore wind turbines** have many advantages thanks to the strength and regularity of sea winds, have reduced impact on landscapes, and enable the creation of larger production units.

This sector is currently experiencing strong growth. With a growth objective of 40,000 MW offshore, it could represent 10% of all electricity production of the European Union by 2020. The cost of the electricity produced is still high (1.5 to 2 times that of the electricity produced by the land wind turbine). A Reduction in the fixed costs of offshore wind turbine facilities requires an increase in the unit power of the machines, which in the medium term will easily exceed 5 MW (compared to a land wind turbine with an average power of around 2 MW).

### French companies are investing

Some 140 French companies are currently contributing to the wind energy sector, from the production of components to the engineering, installation and maintenance of wind turbines. Almost 150 other French companies have also demonstrated an interest in diversifying into the sector.

While France has few wind turbine manufacturers, apart from Vergnet, Alizeo, Alstom Wind and Areva-Multibrid, **it has a rich network of industrial firms with all the expertise needed to manufacture the parts used in wind turbines**, as well as the ability to meet the needs of the assembly, installation and maintenance of wind turbines. The French company RollixDefontaine is, for example, the world leader in ball bearings for wind turbines. Nexans, world leader in the cable industry, is highly active in the field of undersea cables for wind farms.

### The Vergnet Group, specialist in anti-cyclone wind turbines

For more than 20 years, the French Group Vergnet has been designing, manufacturing and marketing wind turbines for the "Proxwind®" areas (local energy generation for rural areas and close to the consumers) and the "Farwind®" areas (areas with limited infrastructures or subject to extreme climatic conditions). The twin-bladed wind turbines of Vergnet, from 275 kW to 1 MW can be assembled without heavy cranes and can be pulled down to the ground in the case of cyclonic alert or any maintenance operations. More than 650 Vergnet wind turbines are in operation worldwide.

### France is deploying wind farms overseas

#### EDF EN: many farms overseas

The EDF Energies Nouvelles group, 50% owned subsidiary of EDF, has constructed several large wind farms, notably in Portugal with Ventominho (240 MW-120 wind turbines), in Italy with Monte Grighine (98.9 MW-43 wind turbines), and in the United States with Shiloh II in California (150 MW-75 wind turbines). In solar power, EDF EN has also constructed many photovoltaic farms, such as Annprior in Canada (23.4 MWc-312,000 modules) and Casatejada in Spain (11.4 MWc-152,400 modules).

#### La Compagnie du Vent, GDF SUEZ Group, in Morocco

La Compagnie du Vent wind farms are constructed, in France and overseas, for third parties or on its own behalf. It owns and uses, in France, a total of 16 wind farms amounting to almost 192 MW. In Morocco, the company has, for example, become established through the installation of two farms, representing a total of 96 wind turbines and an installed power of over 60 MW.



## > Photovoltaic solar

### Photovoltaic solar power is booming

Photovoltaic solar power is currently experiencing a dazzling evolution the world over. Since 1998, the global photovoltaic solar fleet has increased at a rate of 40% per year. In 2009, the installed power capacity for photovoltaic energy production achieved 22 GW.

Following this trend, France has quickly become one of the principal markets in the field of solar power. In 2009, the installed power reached 440 MW, which was an increase of 600% on 2007. The Grenelle Environnement has fixed an objective of 5.4 GW installed power to achieve by 2020.

Thanks to a long experience, the support of the public authorities and large research investments, the French sector has performed well, notably in the field of building integrated photovoltaics.

Around 150 industrial partners of all sizes, major groups and SMEs, are now active in this sector. According to the French Energy Professionals, the number of jobs in the French sector (around 5,500 in 2009) could reach 15,000 by 2012.

Furthermore, all business lines constituting the value chain of crystalline photovoltaics are still being set up. The industrial capacity for the production of modules has thus sharply increased. And the positioning on the second generation of photovoltaic solutions is one of the major ways of expanding this sector in France.

#### The different systems

Photovoltaic energy is used in various ways, either on isolated sites or connected to the electricity network, in large photovoltaic plants or in the private housing sector.



The potential for the installation of photovoltaic panels on buildings is considerable, notably on the roofs of communal housing, commercial or public buildings, agricultural barns or factories. Usually, the collectors are fitted to the existing roof, but it is now possible to integrate them into the tiles or slates in order to improve the appearance. **France has real expertise in building integrated photovoltaics.**

In a **ground plant**, the photovoltaic panels are fixed in accordance with an optimal angle of exposure to the sun or are fitted onto one or two motorized axes, so that the solar collectors follow the trajectory of the sun (solar tracker systems). This results in an output increased of almost 30%.

### Photovoltaic solar power has many applications

#### Photovoltaic plant in Orange les Vignes (Aérowatt)

Bouygues Immobilier, developer of the "Orange les Vignes" retail park, chose Aérowatt to install and operate 12,000 photovoltaic panels integrated into buildings (total power 2.2 MW). For a building open to the public, this is currently the largest system integrated into a building in Europe.

#### Ground photovoltaic plant in Lunel (Southern of France)

Extending over 1.5 hectares, this ground plant has 6,500 photovoltaic modules, which is a maximum electricity power of 505 kW. According to simulations, production of the plant will be 605,900 kWh of electricity per year, which is the equivalent of the consumption of 250 homes. The plant avoids the rejection of 546 tons of CO<sub>2</sub> per year.

#### Tenesol: one of the principal French players in photovoltaic solar power

Subsidiary of the EDF and Total groups, Tenesol designs, markets, installs and operates full systems in all fields of application of photovoltaic solar power in 50 countries. This includes connection to the network, isolated sites, and solar water heaters. The company is particularly involved in the rural electrification of emerging countries (50,000 clients listed in Morocco) and water pumping using solar power (over 4,000 pumps installed, which is 80,000 m<sup>3</sup> water pumped every day).

#### The sun working for water: Photowatt's "solar pumps"

Photowatt is the only French manufacturer with vertically integrated production in the photovoltaic solar sector, and has carried out many projects aimed at providing water to collective facilities away from the principal network, notably in Africa. This is the case in Niger, Chad and Burkina Faso where Photowatt has installed many systems: "solar pumps", pipe systems and drinking fountains (distribution circuit), water towers (storage)... Photowatt has also participated in developing pumping systems in Australia by providing the supply modules.

#### Solar tracking systems: the example of Exosun

Exosun specializes in the construction of ground photovoltaic plants equipped with solar trackers, and has developed Exotrack, an innovative sun tracking concept which can increase the electricity production of modules by 20 to 40% in comparison to a fixed installation.



Photovoltaic panels can be used in combination with other sources of energy.

These **hybrid systems**, generally connected to batteries, considerably increase the autonomy of the producer in isolated areas.

The photovoltaic facility does not necessarily have to be connected to an electricity network.

**It is therefore of great interest for rural electrification, particularly in developing countries** where connection to the electricity network is either impossible or economically unprofitable.

#### Technologies called for

Photovoltaic energy is based on the transformation of solar radiation into electricity energy. It is mainly obtained through two types of cells: crystalline silicon and thin film cells.

**Crystalline silicon** cells are made up of thin wafers of silicon, highly abundant chemical element extracted from sand or quartz. These cells have a good output (14 to 15% for multi-crystalline; 16 to 19% for mono-crystalline). They represent 80 to 90% of the global market.

**Thin film cells** are obtained by depositing one or more semi-conductor and photosensitive films on a glass, plastic or steel support. While the manufacturing cost is lower, the output of the thin film cells is currently less than that of crystalline silicon (5 to 13%).

There are currently three principal thin film technologies: Cadmium Tellure developed principally by American company First Solar; CIGS (copper indium selenium) which is currently in development and has already interested French players such as Saint Gobain and Total; and amorphous silicon, which is under development and has gained the interest of several French start-up companies.



#### A highly Dynamic French sector

In the silicon sector in France, two companies stand out: Photowatt and Emix which manufacture ingots and wafers. A dozen other companies are highly active in the production of cells and modules, including: Auversun, Fonroche Energie, France Watts, Free Energy, Photowatt, PV Alliance, SilliaEnergie, Solaire Direct, Solarezo, Solems, S'Tile, Sunland 21, Tenesol, Voltec Solar.

Components, inverters and monitoring systems are produced by Tenesol. Prysmian produces and markets connectors dedicated to photovoltaic facilities. The Schneider Electric group is continuing its expansion into this sector with the installation of production sites dedicated to monitoring systems, concrete connection stations specifically designed for photovoltaic, inverters, and interconnection boxes and units. Lastly, many French companies are working in the development, installation and operation of projects.

#### Building integrated photovoltaics : a French specificity



France has a highly developed expertise with regard to integrating photovoltaics into buildings and has made this a national priority. The criteria for integration into buildings have been reinforced so that photovoltaic solutions become a part of the roof in their own right, and not an unattractive addition. On the French market in 2009 there were over 80 products which integrated the combined functions of electricity production and waterproofing of roofs and walls.

For example, companies such as Photowatt, Barusch et Fisch and Sora produce photovoltaic tiles. Urbasolar specializes in photovoltaic waterproofing membranes. Photon Power produces solar sheets and a system for integration into glass. Kawneer and APEX BP SOLAR have developed a photovoltaic solution which protects from bad weather and shade.

Midisolaire has developed an integrated system into buildings for agricultural and industrial use making it possible to generate ventilation effects under the modules.

Clipsol manufactures full generators mainly integrated into roofs (capacity of 50,000 m<sup>2</sup>/year), and along with Hiolle Industries has developed an integration macrostructure, the installation of which is undertaken by fields of pre-assembled 20 m<sup>2</sup> photovoltaic panels. Tenesol is developing special products which are adapted to be integrated into buildings in partnership with innovative industrial firms in the building sector (Arcelor MITTAL (steel sheets), Eternit (roof construction materials) and SMAC (building sheathing).

#### Thermal solar power in the agri-food industry (Sicabat/Reunion)

Currently, Sicabat has the largest thermal solar facility in the Reunion island. This has enabled the company to increase its production of water which is necessary for its industrial processes. Constructed by Giordano with financial support of the regional authorities and ADEME, the facility makes it possible to avoid the discharge of 109 tons of CO<sub>2</sub> into the atmosphere and to save more than 40,000 litres of fuel per year (30% reduction). The return on investment time after subsidies was five years.

#### Programme for 85 individual rental houses in La Bâtie-Neuve in the Hautes-Alpes region

Intended for families on low budgets, this programme has received the French very high energy performance (THPE) label. The houses benefit not only from high performing exterior insulation enabling acoustic and thermal wellbeing, but also from thermal solar collectors installed on the roof, covering more than 50% of domestic hot water needs.





## Thermal solar power: many applications for heating

Thermal solar power is an easily workable and inexhaustible energy which does not produce waste or greenhouse gases. Between 1999 and 2006, the growth in the global fleet was 20% a year. The installed thermal solar power in the world at the end of 2006 rose in 2009 to around 174 GW.

France has a recognized expertise in thermal solar power. At the end of 2009, the French fleet represented 1,396 MWth, which is almost 2 million m<sup>2</sup> of panels. Thermal solar power has grown significantly among both individual users and collective installations. The tertiary sector and industry represent a high potential for development. To contribute to this, the French authorities have notably created the "heat fund". Implemented by ADEME, this incentive instrument finances projects for the production of heat from renewable energies in communal housing, communities and companies.

To accelerate the generation of collective solar hot water, Enerplan (professional solar power association) launched its own initiative which is called "So Col". This collaborative platform brings together all business lines involved, such as industrial firms, research offices, installers and operators. It concentrates on the technical, financial and legal aspects of the sector, and on training and advertising. Thanks to this project accelerator, Enerplan plans to increase from 57,000 m<sup>2</sup> installed in 2008 to 70,000 m<sup>2</sup> in 2010, 600,000 m<sup>2</sup> in 2015 and 745,000 m<sup>2</sup> in 2020.



### Technologies with ever growing outputs

Thermal solar power is based on the use of collectors with the role of converting solar radiation into usable heat. Currently, several types of collector are used:

- 1. Glazed flat-plate collectors** are among the most commonly-used collectors. Heat conductor fluid, very often water mixed with food grade anti-freeze, passes into a plated coil under an absorbent sheet, all behind glass, in an insulated box of mineral wool or composite polyurethane foam.
- 2. Vacuum tube collectors** are presented in the form of panels composed of transparent glass tubes of 5 to 15 cm. Their design makes it possible to eliminate loss of heat due to air. In fact, they have an output greater than that of glazed flat-plate collectors.
- 3. Unglazed collectors** are composed of uninsulated black plastic tubes, often bracketed together. With a very good output, unglazed collectors produce temperatures similar to ambient air temperature.
- 4. Air collectors** make it possible to increase the air temperature by 5 to 10°C. They are often used directly for heating or drying agricultural products.

### For individuals or community heating

**Individual solar water heaters (SWH)**, which have been developed for some years, are reliable and can supply between 50 and 80% of the domestic hot water needs of individual homes. Over 36,000 solar water heaters were installed in France in 2009.

Furthermore, many contractors now choose solar power to produce domestic hot water in buildings. For the facility to be efficient and profitable, the hot water requirements need to be regular and spread over the whole year, including during summer when the system is most productive.

**Some sectors are therefore particularly suited to the choice of solar power for the production of domestic hot water, such as hotels, hospitals and retirement homes.**

Many French companies, such as Clipsol and Giordano Industries, manufacture complete systems, including the collectors. Viessman is the leading French manufacturer of solar collectors. Heliopac offers a system combining a low temperature thermal solar collector and a heat pump.

## Thermodynamic solar power: a huge potential in sunny countries

In a thermodynamic solar plant (also called CSP or Concentrating Solar Power plant), the solar radiation received by mirrors is concentrated in order to heat a heat conductor fluid. Through a thermodynamic cycle (gas, steam, combined cycle boilers), this heat is then transformed into electrical energy. Where applicable, the residual heat of the electricity production cycle can enable (by cogeneration) desalination of seawater or production of cold.

The four principal processes currently used are the following: cylindro-parabolic collector plants, Fresnel mirror solar plants, tower plants, and parabolic collector plants.

### CNIM: a Fresnel mirror solar plant

CNIM designs, constructs and commissions concentrating solar power systems.

Specialized in mechanics, steam generation, thermodynamic cycles and turnkey systems, in 2009-2010 the French group developed a pilot concentrating solar power module based on Fresnel mirror technology in the south of France (Ia Seyne-sur-Mer). Constructed out of grade 1 equity, this 50 x 20 metre prototype has 720 m<sup>2</sup> of mirrors directly producing steam at 100 bar.

This construction has supplemented the experience already acquired in tower plants with the construction of the solar boiler of the Thémis plant at the beginning of the 1980s.

**The potential of this technology is huge in countries where direct sun is greater than 2,000 kWh/m<sup>2</sup>/year** (namely certain parts of the southern Europe, the Maghreb, central and western Asia, Oceania, North America, South America and Austral Africa). According to the International Energy Agency, CSP could represent 11.3% of global electricity production in 2050.

In particular, these technologies could meet the Mediterranean Solar Plan objectives. This European project, launched by France, targets the additional construction of 20 GW in renewable energy production capacities by 2020 in the countries in the south bank of the Mediterranean sea.

Many French industrial players work in this sector: the CNIM and its subsidiary Bertin Technologies, Solar Euromed, COMECA, European leader in low voltage services and systems, engineering designers such as Sogreah, and several major French groups that are global leaders in the energy field: Alstom, Areva, EDF, GDF SUEZ, Schneider Electric, Total.

## > Bioenergies: wood, biomass and biofuels

Bioenergies result from the use of plants in heating, electricity production (through cogeneration or methanization) or transport (biofuels).

There are many sources of biomass such as, agriculture, forest use, sea and aquatic environments (algae), residues from industries and human activities, including agri-food, and paper industries, bi-products generated by the transformation of wood, organic waste such as the sludge from purification plants or farm effluents.

### Production of heat and electricity from biomass

Used as fuel for the production of heat or electricity, biomass has many advantages such as, a neutral balance in terms of greenhouse gas emissions, accessibility and varied sources. Lastly, the development of better quality fuels and the technical progress made have, for example, reduced emissions due to the combustion of wood for new generation heating systems in residential housing by almost 55%.

#### Leading French know-how

Biomass is the leading source of renewable energy in France with 46% of production (heat, electricity and fuels). It also represents 71% of production of renewable heat.

Wood is primarily used as fuel to supply wood boilers (in the form of pellets or briquettes) in different environments such as, individual homes, collective heating of buildings, heating networks, industrial usage, notably in the agri-food industry, etc.

On an industrial scale, fruit stones, waste from paper plants, sugar cane bagasse, waste from communities or even biogas from the fermentation of waste are also used as fuels.

France has a great deal of experience in the field of collective heating, with over 1,500 references such as, towns, districts, schools, swimming pools and hospitals. The French domestic wood heating sector is also one of the most dynamic in Europe: around 500,000 systems are sold in France each year and 74% of these systems are manufactured in France. Furthermore, French manufacturers are established on the export market (which represents 20% of their turnover), particularly in the whole of the European Union.

The use, operation and processing of wood as an energy source represents over 60,000 jobs in France. The dynamism of French manufacturers is principally linked to expertise in the iron products sector. Alongside systems manufacturers such as, Cheminées Philippe, Invicta, Godin, Supra, Richard le Droff, and Brisach, the manufacture of domestic wood heating systems enables a number of French foundries to work for the national market and for export (La Fonte Ardennaise, Pebeco, Fonderie de Niederbronn - subsidiary of De Dietrich). Other industrial firms concentrate their activity on the manufacturing of domestic wood heating systems: Poujoulat, European leader in chimney flues, and Eurokera, global leader in glass ceramic products, subsidiary of Saint-Gobain.

Lastly, companies such as Véolia/Dalkia and GDF SUEZ/Cofely have recognized expertise in the field of collective renewable heat facilities, notably using biomass or direct or assisted geothermal energy.

To fully exploit the French potential for bioenergies, incentives have been fixed by the Grenelle Environnement which stipulates:

- a 90% increase in the quantity of biofuel used by the sector between 2006 and 2020,
- a 50% increase in the number of individual homes heated by wood by 2020 (9 million homes equipped, as compared with 6 million currently),
- collective/industrial production of heat and bioelectricity multiplied by 5 by 2020.

### Alternative solutions

#### Collective heating in Besançon

Created in partnership with ADEME and the local communities, this wood heating system combined with an urban heating network produces heat for the equivalent of 12,500 homes. The project will avoid the discharge of over 10,000 tons of carbon gas per year.

#### Wood heating in a hospital

A wood boiler with a power of 2.5 MW supplies heat to 2,500 beds in the hospital of Pontorson (Basse Normandie). The boiler makes it possible to avoid the emission of 1,000 tons of CO<sub>2</sub> / year.

#### Thermal plant of Moule, Guadeloupe

Bagasse, residue of the sugar cane process, is an atypical commodity for producing energy. The thermal cogeneration plant of Moule in Guadeloupe recycles all bagasse produced by the island, which is around 430,000 tons.

#### Cofely: development of a heating network in Soissons

European leader in environmental and energy efficiency services, Cofely is designing, constructing, financing and exploiting a 5 MW wood heating system and its 6 km distribution network.

This biomass will heat the equivalent of 2,000 homes and avoid the emission of around 95,200 tons of CO<sub>2</sub> over the duration of the contract.







## Production of biofuels from biomass

Biofuels produced from biomass can be divided into two categories:

1. biodiesel (intended for diesel engines) from colza, sunflower, soya or palm oil,
2. bioethanol (petrol engines) from the fermentation of sugar cane or beet.

Thanks to a proactive policy in this sector, France is currently the European leader in first generation biofuels.

Biofuels have been developed in order to offer an alternative solution to fossil fuels. They are divided into esters and oils on the one hand, and ethanol and ethers on the other hand.

Esters and oils are used to "add to" and supplement road fuel or heating fuel. With 21 industrial esterification units, France has considerable experience in this sector.

Ethanol and ethers are used as oxygenated additive in the formulation of unleaded petrol. These biofuels, originating from beet or wheat, are produced in 20 industrial bioethanol production units and 4 ETBE (Ethyl Tert-Butyl Ether) industrial transformation units.

**Many French companies have a leading position in this sector:** Diester Industrie and Saipol for the production of biodiesels and Téréos and Cristal Union for ethanol. The current use of biofuels in France each year represents around 2,900,000 tons of oil equivalent (TOE).

According to a recent ADEME study, the sustainability criteria fixed at European level for biofuels are mostly respected in France. From 2011, only biofuels respecting these durability criteria will be able to be recorded and benefit from support systems.

**There are many research projects in France on the development of "second generation" biofuels from cellulose materials such as straw and wood.**

This new generation will enable the use of resources other than food crops and limit competition between usages. A third generation of biofuels is currently being studied. It will make it possible to create fuels from micro-algae whose growth has been accelerated by the absorption of CO<sub>2</sub>.

## France on the frontline

### Dalkia, French leader in the production of energy from biomass

In 2009 Dalkia inaugurated the largest biomass heating system connected to an urban heating network in Cergy Pontoise, with a thermal power of 25 MW. In Poland, its facilities recycle 700,000 tons of biomass and are a replacement for coal (460,000 tons of CO<sub>2</sub> avoided each year). In France, Dalkia is currently constructing the largest biomass cogeneration plant (140 MW thermal and 69 MW electric) on the site of paper manufacturer Smurfit. The plant will recycle every year almost 500,000 tons of sub-products of wood from the site and from the forest biomass.

### Tereos - Deinoe

The agri-industrial group Tereos is specialized in the production of bioethanol from beet, sugar cane and cereals. The 18 units installed in Europe and Brazil produce 1.8 million m<sup>3</sup> of alcohol-ethanol per year. The group is furthermore associated with DEINOVE in a research partnership aiming to produce bioethanol industrially by fermentation of fodder cereals by 2014. This partnership falls within the framework of the Deinol project which has the objective of opening the way to the production of lignocellulosic ethanol (2nd generation) in existing industrial plants.

### Maguin-Interis

Major player in the production of bioethanol and alcohols, Maguin-Interis is specialized in the transformation of plant materials such as beet, sugar cane and cereals, but also the cereal or sugar sorghum and manioc described as "new commodities". Maguin Département Alcool internationally offers the creation of alcohol units on the Turnkey Process concept.

The company is also participating in several research programmes for 2<sup>nd</sup> generation biofuels. It explores in particular the industrialization of new lignocellulosic biomass transformation processes.

## > Hydraulic energy is very widespread in France

Based on water propelling force, hydraulic energy is the third source of electricity production in the world, behind coal and gas.

With an annual production of around 3,000 TWh, hydraulic energy supplies one fifth of global electricity capacities. Global hydraulic energy capacities increased from 1,000 TWh in 1965 to 3,000 TWh today.

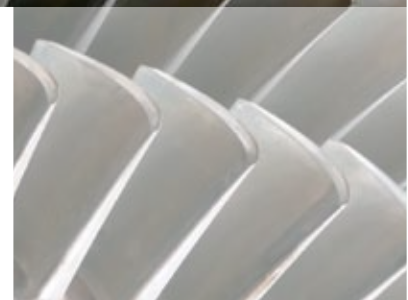
This solid growth is particularly marked in South America and in Asia, leading producer of hydroelectricity with 27% of global production. There is still a very high potential for development in Asia, Latin America and Africa.

**In France, hydraulic energy is in second position, after nuclear, in terms of electricity production (12%).** Currently French production capacities total 23,500 MW for a production of 69 TWh / year.



With vast experience in this field, France plans to further increase its production capacities by around 2,500 MW by 2020, through the optimization of the existing fleet, and the expansion of the small hydroelectricity plant.

In France, hydroelectricity has been used since the end of the 19th century. Electricité de France (EDF) operates 640 dams including 150 with a height of over 20 m.





## Proven technologies implemented over time

The technologies to exploit hydraulic energy are very mature. The kinetic energy of the water is transformed into electricity via an alternator rotor connected to a turbine.

There are different types of hydroelectric plants usually designed according to the geographic characteristics of the sites:

- 1. reservoir power station:** the reservoir created by a dam supplies the turbines of the plant, which produces very quickly a large quantity of energy. This type of plant, which enables the energy to be stored to a certain extent, can be used at the most appropriate times to meet network demand. France has some one hundred lake plants and half of its hydraulic plants possess a reservoir.
- 2. run-of-river station:** having no reservoir, produce cannot be varied and cannot be stored, and is consumed immediately by the network. 55% of the power is guaranteed throughout the year. Over 2,000 **river plants** are operational in France, including nearly 1,700 small hydroelectricity plants.
- 3. pondage power station:** functions with a water reserve corresponding to quite a short period of accumulation. The least busy hours of the day are the time to reconstitute the reserve, which is then used in peak hours.

## A great deal of experience

### Mecamidi

Founded in 1860, Mecamidi designs and manufactures hydroelectric plants up to 30 MW. Specialized in the manufacture of turbines, the company has installed over 500 sites in 80 countries and is now continuing its international expansion in the supply of «turnkey» plants. Mecamidi also offers its clients financing solutions and takes holdings in the plants constructed so as to be a real economic partner.

### Alstom Hydro

Leading worldwide supplier of hydroelectric services and equipment, Alstom has supplied turbines and alternators all over the world for a production of over 450 GW, which is over 25% of the total installed hydroelectricity capacity. Alstom offers turnkey products and solutions responding to the whole range of hydroelectric systems.

### VLH from MJ2 Technologies in Millau: a pilot project

MJ2 Technologies installed the first hydroelectric energy exploitation system using very low waterfalls on the Tarn in Millau. The installed power of 410 kW is equivalent to the consumption of 200 families over a year. The "Very Low Head" (VLH) process, devised by MJ2 Technologies with the aid of the Institut National Polytechnique in Grenoble, avoids the construction of large infrastructures. Moreover, the VLH technology is "fish friendly" like no other and has a very low environmental impact.



## > Geothermal energy is becoming established as a solution

Geothermal energy is the exploitation of heat stored in the earth in the form of electricity or heat.

Currently used in over 70 countries, geothermal energy represents a total power of 27 GW (excluding Heat Pumps). In 2007, 350 high and medium power geothermal facilities were installed around the world, with an average power of around 10 GW.

Having the 3rd largest installed capacity in Europe, France plays an important role in the development of this energy. In 2020 geothermal energy will

contribute to the French energy mix at the level of over 1.3 million tons of oil equivalent (objective set by the Grenelle Environnement).

### The latest technologies

**Very low power geothermal energy** (temperature below 30°C): based on the use of heat pumps, this technology is widely developed for individual houses.

Geothermal sensors of a depth of 50 m coupled with a heat pump enable, for example, a house of 120 m<sup>2</sup> to be heated or cooled.

**Low power geothermal energy** (temperature between 30 and 150°C), is used for heating networks (urban heating networks) or in industrial or agricultural facilities (heating of greenhouses, for example).

**High power geothermal energy** (temperature above 150°C) makes it possible, to transform the heat of the volcanic environments into electricity. The heat is not the only "product" to be recovered; it is sometimes possible to recover by-products or gases dissolved in the geothermal water.







## Recognized French Expertise

France has all the industrial fabric necessary to produce the components of the geothermal circuit (bore pipes, heat exchangers, valves, turbines, alternators, regulation systems, anticorrosion treatment systems and binary loops) for the production of electricity or the supply of heating networks. It also has considerable skill in managing energy services, studying geothermal resources, and the expertise of companies able to undertake the most complex drilling at great depths. French oil operators, such as Total and specialized engineering firms such as Technip also have these skills.

**The Parisian Basin has the largest number of geothermal systems in the world.** These are predominantly low power geothermal energy (heating networks) intended for collective heating. These heating networks are mainly operated by the companies CFG Services, Dalkia and Cafely. The equivalent of 166,000 homes are heated by geothermal heating networks. A standard operation in the Parisian region can heat the equivalent of 4,000 to 5,000 homes. Many of these facilities have been in operation for some twenty years.



In the field of high temperature geothermal facilities for the production of electricity, Alstom has several major references, notably in Indonesia, Guadeloupe and Mexico. A pioneer site for the Caribbean, the Bouillante plant supplies 6% of all electricity consumed in Guadeloupe.

## CFG Services and the BRGM: a cross-disciplinary expertise in the field of geothermal power

CFG Services, subsidiary of the BRGM group, has developed and maintained low power geothermal facilities (heating networks) in the Parisian basin since 1980, exploited principally for collective heating. On an international scale, CFG Services has notably supported a 105 MW geothermal project in El Salvador and supervised the construction of a 20 MW geothermal plant in Indonesia. In 2009, the company conducted studies on the possibility of heating large towns in the north of China by geothermal energy in order to replace coal. CFG Services is also a stakeholder with the BRGM in the geothermal plant of Bouillante, unique pilot project in the Caribbean which supplies around 6% of the electricity consumed in Guadeloupe.

## France is also a pioneer in researching the extraction of heat from Hot Fractured Rocks.

Conducted in partnership with Germany, the pilot project in Soultz-sous-Forêts in Alsace is one of the largest experiments in this technology in the world.

# > France is investing in marine energies

## Innovative solutions

### Tidal power plant of La Rance (Brittany)

The tidal power plant of La Rance (Brittany), launched in 1966, is a world first. With an installed power of 240 MW, the plant produces 550 GWh/year and meets the needs of 220,000 inhabitants. Almost 45 years after being commissioned, the tidal power plant of La Rance is still a leading economic and industrial reference.

### EDF: a pilot marine turbine project in Brittany

After a first machine test in 2011, the 4 marine turbines of Paimpol-Bréhat (Côtes d'Armor - France), with a total 2 MW power, will be connected to the electricity network in 2012 via a specially dimensioned undersea converter. The first test machine will be installed on site in 2011. EDF will benefit from its experience as industrial architect and operator of the tidal power plant in Rance in this first pre-industrial marine turbine farm in the world, constructed in consultation with all local participants.

The sea is an environment rich in energy flows which can be used in various forms: energy from the sea currents, energy from the tides, energy from the waves, sea wind energy, thermal energy of the sea, marine biomass, and osmotic energy.

Throughout the world, tides have an estimated power of 100 GW. With regard to the wave energy, the resources used at a global level could be between 140 and 750 TWh/year. They could meet 10% of global annual electricity demand, according to the World Energy Council.

France has the 2nd largest sea area in the world. The exploitable energy potential is therefore considerable: along the Channel or the Atlantic coast. Great Britain has the greatest European potential, estimated at over 10 GW. France is in 2<sup>nd</sup> position in Europe with a potential of 3 to 5 GW to be installed.

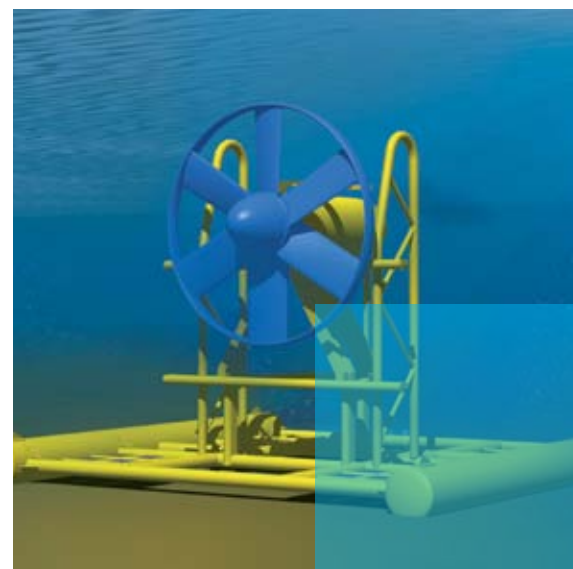
## Highly promising technologies

**Marine current power (hydrokinetics)** is based on the use of the kinetic energy of marine currents. It is used by marine turbines which transform the mechanical energy into electrical energy or into hydraulic energy brought back to land.

**Tidal power** is the use of the potential energy of the tide linked to a difference in level between two water bodies. The principle of tidal power usage is based on the filling of two basins of different heights. The energy extracted is the potential energy between the two bodies of water from the basins. Typically, the upper basin is filled at high tide; the lower basin is emptied at low tide.

**Wave power** is based on the use of waves and the swell generated by the interaction of the winds with the sea surface. The waves have the potential to supply a lasting source of energy which can be transformed into electrical energy by means of energy converters.

**Ocean Thermal Energy (OTE)** consists in using a difference in temperature of at least 20 °C between the deep water and the hot water on the surface in order to produce electricity. It can also produce drinking water, cold for air conditioning and derivative products for aquaculture according to the type of process (open or closed cycle).





**Renewable energies are occupying an ever greater place in the French system for supporting R&D and innovation. Research projects are being deployed in major public institutions, such as CNRS (National Center for Scientific Research) and the French Atomic Energy and Alternative Energies Commission (CEA), as well as in higher education institutions and innovative companies.**

## > Innovation, Research and Development

### ADEME research demonstrator fund: supporting projects in the pre-industrialization stage

Created in 2008, the research demonstrator fund has a budget of 325 million euros for the period 2009-2012. It finances projects which enable pre-industrial experimentation of "breakthrough" technologies. These funds also reduce technological and financial risks while researching well upstream of marketing.

After producing "strategic roadmaps" on each of the priority subjects, calls for declaration of interest (CDI) are regularly launched. Three CDIs relating to marine energies, 2<sup>nd</sup> generation biofuels and intelligent electrical systems and networks integrating renewable energies have been launched in 2009. The 2009-2010 roadmaps give preference to thermodynamic solar power and photovoltaic systems and cells.

Within the framework of a large national loan which aims at giving new impetus to the French industry, **almost 1.35 billion euros** will be invested in the coming years by the French government and managed by ADEME for the implementation of demonstrator projects on renewable and decarbonised energies. If need be, the development of international demonstrator projects will make it possible, to test certain technologies in an environment more favourable to their validation.

### Competitive clusters: French clusters for economic growth and employment

Mainstay of the French public policy for innovation and R&D, these clusters bring together companies, research laboratories and higher education institutions on the same site and over the whole of the value chain, thus uniting the public and private capacities to implement joint innovative projects. This "concentration of knowledge" aims to reinforce R&D, improve the competitiveness and the growth of the French industry.

In order to trigger projects, calls for tenders are launched by the public authorities. These represent 1.5 billion euros in financing for the period 2009-2011. In addition, the French local authorities offer their support and the clusters benefit from a specific tax system. France has about 12 clusters working on the various sectors of renewable energies such as Capenergie Cluster, Derbi Cluster, Mer Bretagne Cluster, and the Mer PACA Cluster.

### Innovators and innovations

#### Bioenergies

#### National Programme for Research into Bioenergies (PNRB)

Financed by the ANR (French National Research Agency) and implemented by ADEME, this research programme relates to the recycling of biomass for energy. It notably finances projects for the development of industrial conversion of the lignocellulose, but also the production of hydrogen and lipids by microorganisms. The socioeconomic impacts of these eco-technologies are also being studied.

#### The Safeoil project – algae biofuel (Mer Bretagne Cluster)

Conducted in Brittany, the Safeoil project has the objective of developing 3<sup>rd</sup> generation biofuels. Safeoil aims to develop an industrial pilot for the production of biodiesel from marine micro-algae. Produced in outdoor pools in old kaolin quarries, these algae contain very high concentrations of oil (up to 35% of their dry mass) and do not require agricultural land or food commodities. The research conducted relates to the whole of the production and recycling chain. In total, the 12 pools developed (of a surface area of 50 ha) could produce up to 14,200 l/ha of biodiesel per year.



#### Wind energy

While offshore wind technology is currently limited by the depth of the sea beds (around 40 m), innovative floating wind turbines will increase the potential of wind energy exploitation at depths exceeding 200 metres.

#### The VERTIWIND project: the French floating vertical axis wind turbine

Within the framework of R&D project bringing together industrial partners (notably TECHNIP for the design and manufacture of the float) and institutional firms, NENUPHAR is currently developing a floating vertical axis wind turbine. Of a height of 90m for a power of 2 MW, equipped with a vertical axis structure to increase its stability, the wind turbine will have a buoyancy only requiring a draught of around ten metres, a structure considerably facilitating the installation, maintenance and towing of the wind turbine.

#### Photovoltaic solar power

The photovoltaic sector is covered by many projects and research institutes, such as the IRDEP and the INES. This sector concentrates over half the French budget for research into renewable energies.

#### The Solar Nano Crystal industrial project

Coordinated by PV Alliance, shared subsidiary of EDF Energies Nouvelles, Photowatt International and the CEA, the Solar Nano Crystal project has the objective of developing and producing high output photovoltaic cells. Seven industrial and scientific players along the value chain of the photovoltaic industry are participating in this 5 year project. Solar Nano Crystal will culminate in the construction of several plants based in France aiming to produce 2 categories of solar cells: the first manufactured on purified silicon (high output), the second using polysilicon (very high output in relation to nanotechnologies).



### Thermodynamic solar power

After having featured among the pioneers in thermodynamic solar power in the 1980s with the Thémis programme, France recently placed concentrated solar power among its priorities for research and demonstrators, notably via ADEME's demonstrator fund.

#### MiCST: a thermodynamic solar micro-plant project

Managed by Schneider Electric in collaboration with 11 French partners and the support of ADEME, the MiCST project aims at developing a thermodynamic solar micro-plant which is easy to install and maintain, and adaptable to any site which is not connected to the electricity network. Solar radiation will be used to heat a thermal energy reserve supplying a thermodynamic machine coupled to a 10 kW alternator.

### Research institutes in the field of solar power

#### IRDEP (Institute for Research and Development of Photovoltaic Energy)

IRDEP, founded by EDF, CNRS and ENSCP (Ecole Nationale Supérieure de Chimie de Paris), has the objective of developing systems with a low production cost in order to contribute to the boom in photovoltaic energy and to increase its share in the energy mix. IRDEP conducts research in two particular fields: thin film solar cells based on CIS (Copper Indium Selenium) material prepared by electrochemistry (CISEL project), and very high output solar cells (PV-THR project).

#### INES (National Institute for Solar Energy)

Created in 2006, INES is dedicated to research, innovation and training on solar power. The institute has notably developed an Industrial Innovation Research and Development platform which aims at reducing and increasing performances of photovoltaic systems for buildings. INES is also developing modelling tools and establishing lasting partnerships with industrial firms.

#### CEA (French Atomic Energy and Alternative Energies Commission)

This public institution is conducting research into various renewable energies such as hydrogen, fuel cells, solar power and biomass. It is working in close collaboration with INES in the fields of thermal and photovoltaic solar power. CEA is also working in partnership with the French Institute of Petroleum (IFP) on the analysis of lignocellulose as source of biofuels.



### Geothermal Energy

#### BRGM (French Geological Survey)

is the leading French public institution in the field of Earth Sciences for managing the resources and risks of the ground and underground. The geothermal energy department of BRGM is participating in the development and promotion of this energy source, in France and internationally. BRGM's research on the subject is oriented according to two themes: developing knowledge of the geothermal resource and its use, in all its forms, and integrating geothermal energy into buildings (heat pumps, heating networks).

#### The European Deep Thermal Energy Programme - Soultz-sous-Forêts

Enhanced Geothermal Systems (EGS) enable the deep extraction of heat stored in hot fractured rocks thanks to the circulation of a fluid through a natural high capacity heat exchanger. Launched in 1987, the French/German Soultz-sous-Forêts programme, in which ADEME and BRGM are notably participating, is currently focusing on a network of three deep wells of over 5,000 m. This system enables to recover 200 litres of water heated to 200 °C every second.

### Marine energies

#### The IFREMER and the marine energies platform

The French Institute for exploitation of the sea is managing a technological platform project on renewable marine energies which will shortly be developed in Brest. This platform will have the purpose of uniting public and private competences in order to successfully conduct R&D projects, and will notably be responsible for the design, financing and management of future test sites in the sea.

#### The DCNS prototype project for thermal energy of the sea: a world first

The DCNS group is engaged in creating a first prototype plant of TME (thermal marine energy) on Reunion Island. TME consists of using the temperature difference that exists naturally between the surface and the depths of the ocean to operate a thermal machine. Of a power of 10 MW, this pilot, called ESPADON, should be operational around 2014.

#### Sabella marine turbine

Developed within the framework of a partnership between industrial firms and public authorities, the marine turbine marketed by SABELLA SAS is characterised by a configuration of juxtaposed turbines on the sea bed, without any footprint on the surface. Unlike other emerging technologies, this concept blends simplicity, robustness and increased reliability. Sabella SAS offers a turnkey solution, from the feasibility study to the construction, installation, operation and maintenance of its marine turbines.







**Following the Grenelle Environnement and the negotiation of a European directive on renewable energies, France has set ambitious objectives in order to increase the share of renewable energies in its energy range. It has put in place incentive mechanisms such as tax credits and the obligation to purchase electricity from renewable energies.**

**Through specific funds for developing and emerging countries, France is financing renewable energy projects in its partner countries.**

## > Public Policies

### The Grenelle Environnement

The Grenelle Environnement is an exemplary consultation process. Using a participative approach, its objective was to prepare long term decisions on the environment and sustainable development in France.

Initiated in 2007, the Grenelle Environnement was organized into six working groups composed of the representatives of five bodies (State, local authorities, employers, employees and environmental NGOs) representing the various participants in sustainable development in France. After an intense stage of public consultation (19 meetings in the regions, 8 internet forums with 11,000 contributions, 2 debates in Parliament, consultation of 31 consultative bodies), the five bodies agreed on 268 precise commitments.

These commitments were then discussed by French Parliament. The Grenelle 1 law, which fixes the principal objectives and orientations, was voted almost unanimously in July 2009. The Grenelle 2 law, adopted in June 2010, defined concrete measures and their implementation.

### The Grenelle Environnement and renewable energies

Since 2007 and the Grenelle Environnement, the production of renewable energies is one of the two mainstays in energy matters, the second being the increase in energy efficiency of buildings.

Thus, France has set itself an objective of 23% renewable energies in the final energy consumption by 2020. This entails increasing the share of renewable energies in the energy range by 20 million tons of oil equivalent in comparison to 2006.

In order to achieve this objective, France has adopted a set of measures:

- the simplification of the administrative procedures for domestic projects,
- the establishment of certification and labels to better identify the main actors and technologies,
- the launch of calls for tenders via the heating fund ("fonds chaleur") and the demonstrators fund in order to stimulate R&D,
- the definition of quantitative objectives within the framework of Multi-Annual Production Investment Programme (PPI),
- the creation of wind development zones in order to ensure the controlled development of wind energy,
- the establishment of legislation with regard to the environment and urban development for land photovoltaic facilities,
- the establishment of regional systems with regard to climate, air and energy: Territorial Energy Climate Plans (PCET).



### The Mediterranean Solar Plan (MSP)

The MSP is one of the six major initiatives of the Union for the Mediterranean (UfM) launched in Paris on 13 July 2008. It aims to help the Mediterranean region and the European Union in addressing the major challenges of energy and climate.

The MSP is based on two major objectives:

- the additional construction of 20 GW in capacities for production of renewable energy by 2020 in the Mediterranean countries concerned,
- making significant energy savings in the Mediterranean area by 2020.

#### Objectives for development of electricity production with renewable energies

Renewable energies		Objectives at 31 December 2012 (MW)	Objectives at 31 December 2020 (MW)
Sun radiation energies		1,100	5,400
Biomass		520	2,300
Wind and marine energy	total	11,500	25,000
	land	10,500	19,000
	sea	1,000	6,000
Hydroelectric production		-	3,000





## The Multi-Annual Production Investment Programme (PPI)

Through the Multi-Annual Production Investment Programme (PPI), France is planning investments in electricity production resources in order to guarantee security of electricity supply. Environmental aspects and renewable energies occupy a considerable part of the PPI, notably for the development of renewable energies.

## Increasing the production capacity

If the electricity generation capacities do not meet the PPI objectives, the government may launch calls for tenders. They enable the selected facilities to benefit from preferential electricity purchase tariffs.

In the field of renewable energies, several calls for tenders have already been launched:

- two calls for tenders for production facilities of electricity from wind (land wind turbines and sea wind turbines),
- three calls for tenders for production facilities of electricity from biomass,
- one call for tenders for the commissioning of solar plants.

Within the framework of the heating fund ("fonds chaleur"), ADEME launched an initial call for tenders for the year 2009 dedicated to the sectors of industry, agricultural and private tertiary over the entire territory. ADEME planned to subsidise between 50 and 100 facilities producing over 1,000 tons of oil equivalent per year for a budget of about 50 million euros.

## Electricity purchase obligation

In order to create favourable conditions to the development of renewable energies, France has set up legislation on electricity purchase obligation. This stipulates that the electricity produced by renewable energy facilities must be bought by Electricité de France (EDF) or the other distributors at a tariff fixed by the government and higher than the market.

Each sector is subject to a specific price list drawn up by the Ministers for the Economy and Energy, after advice of the Higher Energy Council and the Energy Regulation Committee.

The purchase prices are established with contract durations of 15 to 20 years and according to the specificities of each energy; for example, for hydraulic, the prices fixed since 1st March 2007 are 6.07 c€/kWh + bonus between 0.5 and 2.5 for small facilities + bonus between 0 and 1.68 c€/kWh in winter, according to the regularity of production; for wind (land) the prices fixed since 17 November 2008 are 8.2 c€/kWh for 10 years, then between 2.8 and 8.2 c€/kWh for 5 years depending on the sites.

## Tax credit

In 2005 France established a tax credit intended for individual homes, awarding up to 50% of expenses for equipment using renewable energies or reinforcing energy efficiency. It applies, for example, to heating equipment (condensing boilers), insulation materials, heating regulation systems, and equipment for connection to certain heating networks supplied by renewable energies or cogeneration facilities.

Since the establishment of the tax credit and the purchase tariff, the photovoltaic market in France has been growing steadily (increase in the number of facilities on average by over 100% per year).

## Renewable heating fund

Representing around one third of final energy consumption in France, heat is principally produced by imported fossil fuels. However, production of heat from renewable energies has a high potential in France.

The "Heating Fund" established in France finances projects in this sector. With a budget of one billion euros for 2009-2011, it is made of investment subsidies or aid per kilowatt/hour renewable produced, even through a mixture of these two types of subsidy.

The sectors concerned are biomass, thermal solar power, deep thermal energy, geothermal heat pumps, unavoidable heat, such as that from household waste incineration plants (UIOM), and biogas. The recycling of residual heat from the incineration of household waste and the recycling of biogases derived from methanogenesis are two priorities of the Heating Fund.



## Other measures to encourage the development of renewable energies

- **The Planning law fixing the Orientation** of the France Energy Policy (POPE law) establishes quantitative objectives and mobilising programmes for energy savings and the development of renewable energies. It also provides an "energy for development" plan intended to extend access to energy services in developing countries.
- **Since 1992 biofuels have benefited from a partial exemption from the domestic consumption tax (TIC)** which offsets the additional cost in production of biofuels in relation to fossil fuels. This tax exemption is granted to biofuels produced by approved units.
- The development of hydraulic energy is facilitated by various measures recorded in the successive water laws, the fishing law and the guidelines for development and management of water (SDAGE). Many hydroelectric facilities have also obtained the environmental certification ISO 14001 guaranteeing respect for the regulations and targeting continuing improvement of environmental performances.





## Financing

### FIDEME (Investment Fund for Environment and Energy Management)

The FIDEME®, which has a budget of € 45m, is intended to facilitate the financing of projects in the sectors of energy management (including renewable energies) and waste recycling in France. The FIDEME® participates in investment projects of several million euros, and offers intermediate financing between the equity of the project owners and the classic bank debt.



### FASEP – Green Innovation and Studies (for emerging countries)

The FASEP is an instrument of donation for a local beneficiary (central government, provincial government, municipality, and technical agencies) amounting to around 400,000 euros. It is dedicated to the financing of feasibility studies for a given project conducted by a French company. The financing for the project must be identified (public or private, bilateral or multilateral).

The budget allocated to the FASEP procedure amounts to around € 20m per year. It concerns the following sectors: drinking water, sanitation, solid waste, water resources management, environmental protection (renewable energies, project mechanisms) and energy efficiency.

The following types of intervention are supported: project preparation studies for construction and/or exploitation of infrastructures, feasibility studies, overview preliminary drafts and detailed preliminary drafts, technical assistance in the preparation or completion of projects, institutional cooperation for economic purposes.

Another fund called FASEP “green innovation” finances pilot and demonstrator projects promoting French green technology in emerging countries.

### Clean Development Mechanism (CDM)

Instituted by the Kyoto Protocol, the CDM enables companies from industrialised countries to undertake and/or co-finance projects for the reduction of greenhouse gas emissions in developing countries. In return, the investor obtains “carbon credits” corresponding to the emissions avoided through the implementation of the project.

The objective is to encourage investments in developing countries and encourage the transfer of environmentally friendly technologies.

Until now, two thirds of projects registered with the United Nations have been concentrated in Asia, with the remaining third in Latin America. Similarly, almost two thirds of the projects pertain to energy efficiency and the substitution of renewable energies for fossil fuels. French companies have participated in a large number of CDM projects on renewable energies.

### FFEM (French Global Environment Facility)

The FFEM is a bilateral public fund created in 1994 by the French government, following the Rio Summit. This French instrument for cooperation and development cofinances development projects up to 50% of the total amount of a project.

Its purpose is to link the protection of the global environment and local development via sustainable development projects on the following themes: biodiversity, combating climatic change, international water management, combating degradation of the land, treatment of persistent organic pollutants.

## Climate/Air/Energy Plan in Brazil

On behalf of the Regional Agency for Environment and Management Energy of the State of Rio Grande do Sul in Brazil, the French companies Voltalia and Enviroconsult are conducting a FASEP study relating to the establishment of a Climate/Air/ Energy Plan.

This study had to establish, at a local level, an analysis and mapping of polluting greenhouse gas emissions in the Metropolitan Region of Porto Alegre. It also contains a plan for management of the air quality and an action plan for reduction of CO<sub>2</sub> emissions. At a regional level, the study evaluates the potential CO<sub>2</sub> reductions achievable from the establishment of projects based on renewable energies (wind, biomass/ biogas, hydro) eligible for the Clean Development Mechanism (CDM).

## Renewable energies in China

The development of renewable energies is one of the priorities of the Chinese government, which plans to raise the share of renewable energies in the primary energy mix to 10% in 2010 and 15% in 2020. Within the framework of the CDM, the French Development Agency (AFD) has financed the construction of a wind farm in the municipality of Dali (province of Yunnan). The loan of € 30m allowed to install 41 aerogenerators in the upper parts of the town, thus avoiding 50,000 tons of CO<sub>2</sub> emissions per year.

## The “Sustainable Mauritius” (MID) project

Launched in 2007, the MID project aims at reducing the dependence of Mauritius on the import of fossil fuel. It reinforces the capacities of the member authorities and the “MID Fund” and supports the launch of operations, particularly in the field of renewable energies and energy efficiency.

With a subsidy of 1 million euros, France is offering support through expertise and assistance. The total cost of the project is estimated at € 2.4m, to which can be added expected investments of over € 80m from economic players.





**In the renewable energies sector, over 700 private consultancies and research offices in France offer their services of consulting, training, audit and project monitoring. State and semi-State organisations also offer a very high quality service in terms of consulting and training.**

## > Consulting and Training

Almost 400 training courses relative to the business lines and techniques are available in France from the Certificat d'Aptitude Professionnelle (Certificate in Professional Skills) to the University Master's degree: professional organizations such as "Les Compagnons du Soleil", the "Grandes Ecoles" (Ecoles des Mines, Supélec), and the Universities all offer specialized training.

It should be noted that some schools, such as Mines ParisTech, give courses in English.

Business schools offer training adapted to the markets development. The professional colleges are training technicians and installers on the basis of Professional Baccalaureates.

The continuing training of professionals is also assured by many organizations with a competence recognized on an international level, such as ADEME, CNAM, Gretas, and Cesi. Training with FEEBAT reinforce the competence of the Building trades.

### Public institutions

#### ADEME (French Environment and Energy Management Agency)

ADEME proposes training in the field of renewable energies, mainly targeting private participants looking to improve their ability and make their behaviour more sustainable:

- **Wood: energy in the community and the tertiary sector.** This training notably teaches participants to develop a collective wood heating system and analyse the project from an economic and environmental point of view. It also offers knowledge on the fundamental concepts of a collective wood heating system and the various means of management and securing of the wood reserves.
- **Large wind turbines: Total or partial training of professionals on conducting a wind project.** The training begins with an "inventory" of the wind market and covers all the different institutional, technical, regulatory, administrative and financial aspects. Participants acquire capacities of analysis of the technical and economic feasibility of the project, the possibility of connection, the maintenance costs and the choice of financing. The training is conducted by the Cabinet Métrol, specialized in the field of renewable energies and eco-technologies.

#### The CNAM ("Conservatoire National des Arts et Métiers").

Located at Nancy, the CNAM offers a 360 hour training course to technicians in energy management, with the following main subjects:

- renewable energies,
- traditional energies,
- heat pumps,
- air treatment,
- management, regulation, health and safety,
- refrigeration and air conditioning technologies.

#### • PHOTON: technical implementation and monitoring of photovoltaic systems.

With this training, the participants are capable of understanding the photovoltaic sector in terms of network and line extension and conducting a feasibility study of the project. It contains a methodology to be applied when conducting the project (dimensioning, implementation, operation, maintenance, monitoring and promotion of the system).

#### • PHOTON NETWORK: ADEME offers training on photovoltaic systems connected to the electricity distribution network.

#### • Thermal solar power: production of collective domestic hot water.

ADEME proposes training on the use of thermal solar power in the production of collective domestic hot water. The different stages of assembly of a project are studied, such as feasibility, financing, dimensioning, implementation and operation.

#### • Collective and tertiary geothermal heat pumps.

In partnership with BRGM, ADEME offers training mainly targeting professionals in the geothermal sector. Its objective is to develop essential skills for the assembly of a project for collective and tertiary geothermal heat pumps.

#### BRGM (French geological survey)

Active in over 40 countries, the BRGM offers its services (expertise, technical assistance, training) in the fields of Earth Sciences to industrial firms, and also to governments and the various actors of civil society. In France, in the field of geothermal energy the BRGM has developed two training modules in collaboration with ADEME:

- "Introduction to and raising awareness of geothermal power",
- "Collective and tertiary geothermal heat pumps: assembly of a project".

### Consultancies and research offices

#### ARTELIA

Artelia is a European consultancy and engineering firm specialized in the fields of water, the environment, energy and urban development. It supports its public and private clients in the preparation, design and implementation of their strategies, their projects and their investments. The group is very active in the field of innovation and participates actively in national and European research programmes. Artelia is also well established internationally with 8 subsidiaries (Algeria, China, Cyprus, Egypt, Arab Emirates, Madagascar, Morocco and Poland). It has references in over 150 countries.

Other international companies offer specialized training, such as Egis BCOM and Burgéap.





## > Institutions

### Private institutions

Directory of French renewable energy professionals - [www.energies-renouvelables.org](http://www.energies-renouvelables.org)  
 Directory of French eco-companies - [www.eco-entreprises.fr](http://www.eco-entreprises.fr)

#### French Energy Professionals

(SER : "Syndicat des Energies Renouvelables")

Brings together thousands of companies, designers, industrial firms, installers and specialized professional associations representing the various renewable energy sectors.

[www.enr.fr](http://www.enr.fr)

#### Sectoral professional associations:

- AFGth - Geothermal Energy Association
- AFPAC - French Association for Heat Pumps  
[www.afpac.org](http://www.afpac.org)
- SOLER - French group of professionals in photovoltaic solar power
- ENERPLAN - Professional solar power association  
[www.enerplan.asso.fr](http://www.enerplan.asso.fr)
- FEE - French Wind Energy Association  
[www.fee.asso.fr](http://www.fee.asso.fr)

#### Windustry France

Collaborative platform developed and supported by the French Energy Professionals with the objective of identifying and raising awareness of French participants that may take part in the development of the wind turbine industrial sector.

[www.windustry.fr](http://www.windustry.fr)  
[www.suivi-eolien.com](http://www.suivi-eolien.com)

#### Observ'ER

Oversees, informs and proposes solutions in the field of renewable energies, quantifies and qualifies the progress of sciences, techniques and industry in each of the disciplines. The Observatoire publishes a barometer of renewable energies.

[www.energies-renouvelables.org](http://www.energies-renouvelables.org)

#### CLER (Renewable Energy Information Center)

Association composed of 180 French professionals developing regional, national and international actions in the field of renewable energies and energy management, drawing on the members of its network.

[www.cler.org](http://www.cler.org)

#### GERES

Not-for-profit association created in 1976, conducting innovative sustainable development projects in France, Europe, Africa and Asia.

[www.geres.eu](http://www.geres.eu)

#### Foundation for World Energy

The foundation implements decentralised rural electricity projects in Africa, Madagascar, Southeast Asia, India, China, the Caribbean countries and the Pacific zone.

[www.energies-renouvelables.org](http://www.energies-renouvelables.org)

#### PEXE

Association for the promotion and international development of eco-companies of France, with the objective of reinforcing the individual and collective competitiveness of eco-companies, creating a sector of excellence in the field of eco-activities.

The association brings together the networks of French eco-companies, representing over 3,500 eco-companies.

[www.pexe.fr](http://www.pexe.fr)



### Competitive clusters

Clusters recognized individually by the French State, the "competitive clusters" bring together private companies, higher education institutions and public or private research organizations. Their purpose is to work in synergy to implement economic development projects for innovation. The main competitive clusters in the field of renewable energies are as follows:

#### Capenergies ([www.capenergies.fr](http://www.capenergies.fr))

Management of energy demand and renewable energies  
 Provence-Alpes-Côte d'Azur, Corsica, Guadeloupe, Reunion and Principality of Monaco regions

#### Derbi ([www.pole-derbi.com](http://www.pole-derbi.com))

Renewable energies in buildings and industry  
 Languedoc-Roussillon region

#### Tenerrdis ([www.tenerrdis.fr](http://www.tenerrdis.fr))

New energy technologies, renewable energies  
 Rhône-Alpes region

#### Mer Bretagne Cluster (<http://www.pole-mer-bretagne.com>)

#### Mer PACA Cluster (<http://www.polemerpaca.com>)

Innovative collaborative projects in the shipping sector, including with regard to the exploitation of marine energy resources  
 Based in Brittany and Alpes Côte d'Azur region

#### IAR, Industrie et Agroressources ([www.iar-pole.com](http://www.iar-pole.com))

Non-food upgrading of agricultural products  
 Champagne-Ardenne and Picardie regions

## Public institutions

### Ministry for Ecology, Energy, Sustainable Development and Sea (MEEDDM)

Defines and implements French public policy relative to sustainable development. The Directorate General for Energy and Climate (DGE) is notably responsible for defining and implementing policies in the field of energy, including renewable energies. The Directorate of European and International Affairs (DAEI) is in charge of promoting French experience internationally.

[www.developpement-durable.gouv.fr](http://www.developpement-durable.gouv.fr)

### Ministry for the Economy, Industry and Employment

Responsible for French economic and employment policy, this ministry is notably in charge of the industrial policy and support to new technologies and companies.

[www.economie.gouv.fr](http://www.economie.gouv.fr)

### ADEME (French Environment and Energy Management Agency)

French public institution active in the implementation of public policy in the field of environment and energy management. The agency stimulates, animates, coordinates, facilitates and implements operations in the following fields: waste management, soil protection, energy efficiency and renewable energies, air quality and noise reduction. ADEME provides expertise and advisory services to companies, local authorities, government bodies and the public at large.

[www.ademe.fr](http://www.ademe.fr)

### Club ADEME International

Network composed of some hundred French eco-companies active on the global sustainable development market, supporting its members in the development of innovative projects and partnerships internationally.

[www.clubinternational.ademe.fr](http://www.clubinternational.ademe.fr)

### Ubifrance

French agency for the international development of companies, has its own network solely dedicated to supporting SMEs on the foreign markets. The 22 regional branches, partners of the Chambers of Commerce and Industry, contribute to mobilizing companies with potential for export. The 63 economic missions present in 44 countries support the companies on site.

[www.ubifrance.fr](http://www.ubifrance.fr)

### AFD (French Development Agency)

Key operator for the French public development aid, the AFD is a public institution responsible for financing economic and social development projects in many developing countries.

[www.afd.fr](http://www.afd.fr)

### BRGM (French Geological Survey)

Public institution in the field of Earth Sciences for the management of resources and risks (ground and underground) particularly in the field of geothermal energy.

[www.brgm.fr](http://www.brgm.fr) and [www.geothermie-perspectives.fr](http://www.geothermie-perspectives.fr)

### CEA2

French public scientific research organization working in the fields of energy, defence, information technologies, life sciences and health, supporting the development in new energy technologies: photovoltaic solar, electric batteries, hydrogen, biomass, etc.

[www.cea.fr](http://www.cea.fr)



Solar measuring station, Bertin Technologies



**ADEME**



French Environment &  
 Energy Management Agency

**UBIFRANCE**  
 AND THE  
 FRENCH TRADE COMMISSIONS

[www.ubifrance.fr](http://www.ubifrance.fr)

