# EUSUSTEL

European Sustainable Electricity
Comprehensive Analysis of Future European Demand and
Generation of European Electricity and its Security of Supply

**WP1: Country-wise analysis for EU-25**

# HORIZONTAL DESCRIPTION OF FRANCE

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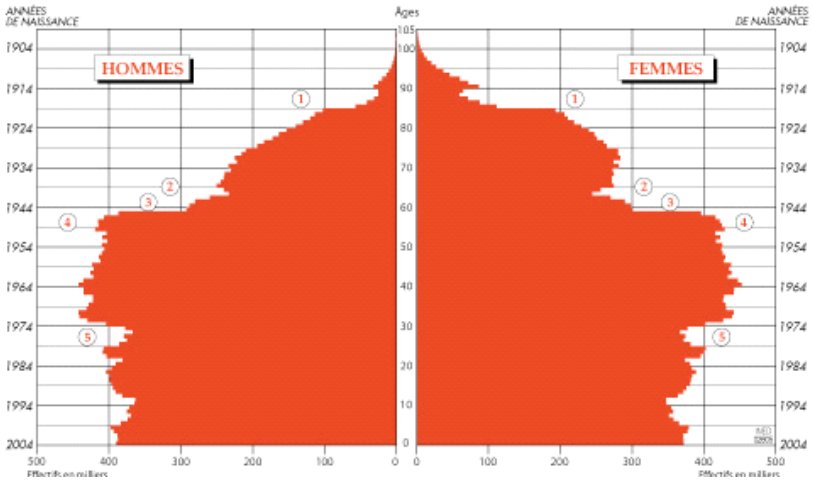
# 1 / Factual information

## 1. 1 Geographical description

France is a large country, with a surface of 544 435 km$^2$, extending on 1 000 km from north to south, and 900 km from east to west. It is the **largest country of the European Union**.
Areas of low altitude make the major part of the relief: two sedimentary basins (Parisian and Aquitan) cover 2/5 of the surface (220 000 km$^2$).
There are two mountainous areas reaching up to 3 400 m (Pyrenees in the south) and 4 800 m (Alps in the east). ,
There are three other mountainous areas of smaller height, located in the middle and in the east of the country.
Five rivers cross the country on a distance of about 3 100 km and can provide, when it is favorable, hydraulic power. Large dams have been built to exploit this resource.
A large part of the area of France is devoted to agriculture (**54% of lands are cultivable** / 293 995 km$^2$), with **large protected zones** (72 400 km$^2$) and forests (172 000 km$^2$).
The French borders make 5 660 km in length, more than half of it being maritime coasts, along the Mediterranean Sea, the Atlantic Ocean, the Channel, and the North Sea. The remaining borders are partly mountains or rivers.
Finally, **climate is moderate**: Mediterranean in the south, oceanic in the west and continental elsewhere, with an annual sunshine period between 1 750 and 3 000 hours/year.
Along the year, we have moderate rains, pleasant temperatures. However, cold periods and heat waves can happen.

## 1. 2 Demography

The French population is about **62,4 millions** in 2005, and will probably be larger than 63 millions in 2010.
Three big towns and theirs suburbs concentrate more than 15 millions people (Paris, Lyon and Marseille). There are about one hundred cities with more than 100 000 inhabitants, the number of **city dwellers is about 45 millions**, which represent close to 75% of the total population. There are in all 38 000 communes, 90% of them have less than 2 000 inhabitants.
Therefore, only 15 millions people live in the countryside, and this number is steadily decreasing.
The population density is **109 inhabitants/km$^2$**, lower than the European average, which is 112 inhabitants/km$^2$.
There are 25.5 millions households, made up in the average of 2.4 people, and the working population amounts to 27 millions. In 2010, there will probably be 28.7 millions households made up of 2.2 people.
The **life expectancy** is **80.2 years** (83.8 for women, 76.7 for men) and the birthrate is 1.7 children by woman.
The population pyramid shows a distribution, with a peak around 30-60 years and a **mean of 38 years old**.



Population pyramid of France 2004

## 1. 3 Economical situation

The **Gross Domestic Product was 1 416.9 billions euros** in 2000, and will probably be 1 791.9 in 2010, i.e. an increase of 0.4% per year. The GDP/person was 23 360 euros in 2000 and is expected to be 28 380 in 2010.
In parallel to the GDP, the households consumption will also increase from 756.96 billions euros in 2000 to 959.5 billions euros in 2010.
Most of the Gross Value Added has been generated in 2000 by services (922.4 millions euros ≈ 70%), and this situation is likely to continue with, in 2010: 1190.4 millions euros ≈ 72%.

There are about **2.4 millions companies** in France, mainly in services and trade. France exports transport equipments, planes, chemical and pharmaceutical products, iron and steel… and import cars, machines and other goods. **Energy** is one of the most important growth promoters: in 2004, it represented **1.8% of the GDP**, billions of euros of imports, and 230 000 jobs.

## 1. 4 Energy

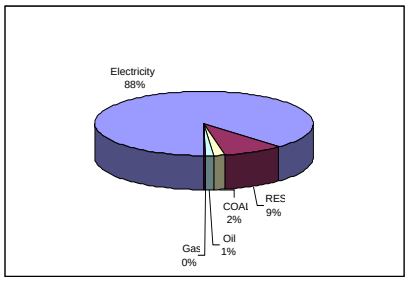
National production of primary energy is 1 611 TWh. It ensures an **energetic independence of 50.2%** in 2004 (gross inland consumption = 3 209 TWh), principally because of **nuclear and hydroelectric power** (France has only **0.01% of fossil fuels reserves** in the world).
An extrapolation of 2004 data's leads to a consumption of primary energy is about 3313 TWh in 2005 (53 MWh/year/inhabitant), the final consumption is about 1 894 TWh, slowly growing every year (except between 2002 and 2003), as we can see in next tables.
The conversion rate employed is 1MWh = 0.086 Toe / 1 Toe = 11.63 MWh

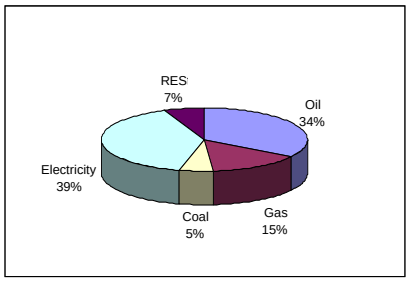
| Unit TWh | Gross Primary Production | | | Gross Inland Consumption | | |
|---|---|---|---|---|---|---|
| | 2000 | 2005 | Annual change | 2000 | 2005 | Annual change |
| Oil | 29 | 14 | -13,6 | 1031 | 1128 | 1,8 |
| Gas | 18 | 6 | -19,7 | 410 | 484 | 3,4 |
| Coal | 27 | 27 | 0,0 | 177 | 172 | -0,6 |
| Electricity | 1317 | 1443 | 1,8 | 1180 | 1314 | 2,2 |
| RESt | 132 | 148 | 2,3 | 200 | 216 | 1,6 |
| **Total** | **1523** | **1638** | **1,5** | **2998** | **3313** | **2,0** |

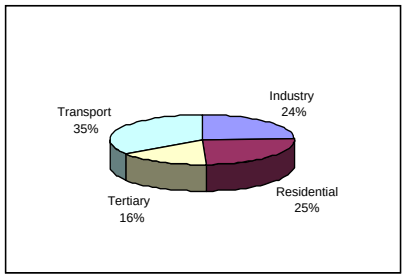
Energy balance of France

| Unit TWh | 2000 | 2005 | Annual change |
|---|---|---|---|
| Industry | 409 | 456 | 2,2 |
| Residential | 449 | 477 | 1,2 |
| Tertiary | 291 | 310 | 1,3 |
| Transport | 598 | 650 | 1,7 |
| **Total** | **1747** | **1894** | **1,6** |

Final energy demand by sector




Gross primary production | Gross inland consumption | Final energy demand

As for all the OECD countries, **oil** is an important part of the primary energy consumption in France (**34% in 2005**) but less than **electricity (39%)**. Gas, which represents only 15%, has an annual change of about 3.4% for the period 2000/2005. Coal and renewable energies are less significant, with respectively only 5% and 7% of the consumption.
In the final energy demand, **transport** represents the most important part with **35%** associated to road transport (cars, buses and trucks). It is followed by industry and residential areas, which represent each 25% of the demand. The tertiary sector represents 16% of the 1 894 TWh energy consumption.
Primary and final energy intensity are decreasing, respectively -0.4% and -0.9% per year in the average since 1990. This decreasing rate accelerates itself during the two last years: respectively –1.6% primary and –1.9% final average annual rate, mainly due to economic growth and higher energy prices.
**Consumption per inhabitant** remains stable: 53.15 MWh for primary energy and 31 MWh for final energy in 2004.

National production of fossil fuels has notably decreased with closing the last coal mine in 2004. On the other hand, renewable energies production grows by (+2.1% in 2004), especially for wind power (+47%), which reaches 573 GWh in 2004.

The **potential of renewable energies** is sizeable: 700 000 TWh/year are directly received from the sun on the French territory, a potential of wind energy about 12 000 MWe, for average potential production of 100 TWh/year, geothermal resources (low temperature <100°C) of 67 GWh/year, a potential power of wave by 30 kW per meter in Gascogne Gulf, and also a potential of energy from biomass about 335 MWh/year.
Hydropower is the first renewable energy used in France, but a new potential of 1300 MW can be developed by some renovations (300 MW) and new building (1000 MW).
Moreover, France has the most important generating capacity operating of energy from tides, with the La Rance plant: 250 MWe, 91% of world tidal power since 1966.
As a matter of fact, France is the **first producer**, in absolute value, **of renewable energy in Europe**, thanks to hydropower.

## 1. 5 Electricity

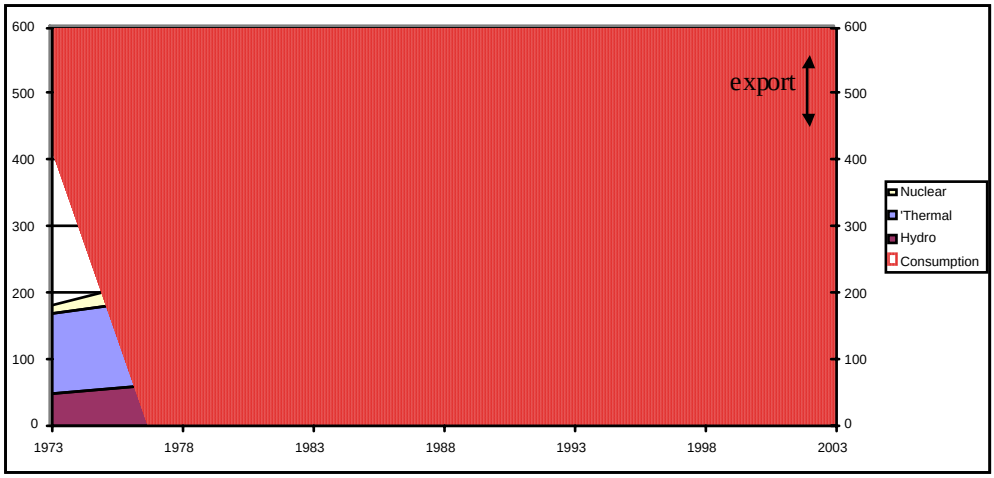
Due to a lack of inland energetic resources, France electricity production relies heavily on **nuclear power**, which produces most of the electricity of the country (**78.1% in 2004**). There are **58 nuclear reactors** (54% of the installed capacity with 63.4GW) set up on 19 sites. It is the second number in the world, after USA. It is characterized by an important standardization and a short period of construction. The consequence of this is a **low price for electricity**, which remains stable in time. Building nuclear plants has been decided around the seventies because of the oil crisis. It turns out that it was a good choice in regards of the amount of currency saved up.
For a long time, **hydropower** has been the main source of electricity in France. It represents now 24% of the installed capacity with 27.9GW. The dams have been built mainly in the 1940's and 1960's. Some of the dams are used to store electricity during off-peak hours to be used during peak hours and to regulate the electricity network (1% of the electricity).
**Thermal power** (22% of the installed capacity with 25.4GW) is especially used for the peak demand.

| | | TWh | % | installed capacity (GW) |
|---|---|---|---|---|
| Production | Nuclear | 426,8 | 78,1 | 63,4 |
| | Hydro | 64,5 | 10,1 | 27,9 |
| | Other thermal power and renewable | 55,3 | 11,8 | 25,4 |
| | **Total** | **546,6** | **100** | **116,7** |
| | | | | 04/03 (%) |
| Consumption | Steel | 11 | 2,6 | 0,5 |
| | Insdustry | 133 | 31,5 | 1,2 |
| | Housing and service | 266 | 63,0 | 1,5 |
| | Transport | 12 | 2,8 | 2,5 |
| | **Total** | **422** | **100,0** | 1,4 |

Electricity repartition for 2004 (RTE)

The **request for electricity** is more important in winter and depends very much on the external temperature.
A decrease of 1° Celsius increases the demand by 1000 MW (about one nuclear reactor). The peak load, in winter, was 86 GW (02/2005) and, in summer, 57 GW (07/2003).

The **evolution of electricity production park** over the past decades has allowed a significant decrease of thermal plants. The extensive use of hydropower and nuclear power has allowed to strongly decrease greenhouse gases emissions. It has also been possible to export quite a lot of electricity since the 80's. On the contrary to fossil fuels, nuclear electricity depends little upon the price of uranium (uranium's costs represent only 15% of the nuclear electricity, while coal's costs represent 34%, gas 63% and oil 78%). As far as natural uranium is concerned, an increase by a factor of 10 of its price would lead to an increase of the price of the kWh lower than 40%.




Evolution of electricity production and consumption 1973/2003

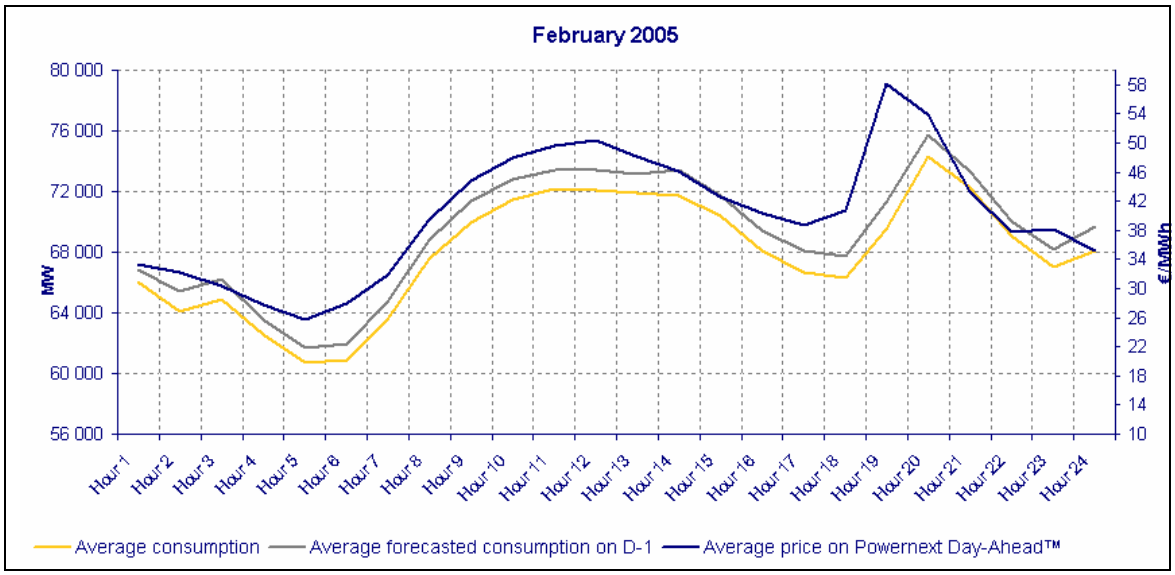
The **interconnections** with European neighbors have increased by 21% since 2003. The French electrical network has an important capability of exchange with other countries (about 9% of the installed capacity for electricity production) and it will increase: 3500 MW with Belgium, 3000 MW with Switzerland, 2500 MW with Italy, 2000 MW with Great Britain and 1200 MW with Spain. The main parts of these interconnections have to be set up to increase security and decrease overloading. The **French balance of export was about 60 TWh** in 2004 but slightly decreases since two years.

| | Input | Output |
|---|---|---|
| | TWh | TWh |
| Belgium, Germany, Switzerland and Italy | 26 | 71,9 |
| Spain | 1,9 | 7,2 |
| Great Britain | 1,2 | 10,5 |
| Total | **29,1** | **89,6** |

European exchange with France 2004 (RTE)

There are **four electricity producers** in France. One of them, **EDF** (Electricité de France) controls **90%** of production. The others, **SNET**, **CNR** (Electrabel) and **SHEM** (Electrabel), have some production capacities in France (6200 MW), mainly in hydro and thermal power, and can buy electricity through the **Virtual Power Plant** provided by EDF (6000 MW). This enables them, and other 19 independent suppliers, to control in fact 20% of the production.

Let us now have a look about **trading and market**. Because of the liberalization of the sector, electricity has become a commercial good. **Powernext** is a multilateral trading facility, in charge of managing an optional and anonymous organized exchange in France. With a trading of 14 TWh (day ahead) and 13 TWh (future) in 2004, that is to say 5% of the total market, Powernext will have a more and more significant influence on the price making. Before deregulation, the price of electricity was not volatile, but now its evolution will depend on weather conditions, global demand, and delay of forecasting… The **volatility** is significant during high demand period (winter) as well as for peculiar situations like in summer 2003 during the scorching heat (environmental limits of thermal and nuclear plants, almost no wind in Germany…). The price of electricity strongly depends on the demand, which varies from time to time. For a high level of demand, particularly during winter, producers have to start thermal plants like coal plants, which are expensive, increase the price of electricity and emit greenhouse gases. In the average, the price is about **30€/MWh**, but was over that value several times and reached values up to 130€/MWh. A special mention should be done about summer 2003 where, exceptionally, a price of 1000€/MWh has been reached.
Storing electricity, with hydraulics, allows decreasing the pressure on the demand. Large-scale solutions are nevertheless insufficient and many electricity storage technologies are still too expensive at the moment. However, storage at the electric grid level and at consumer level will increase the supplying security.




Price evolution during a day of February 2005

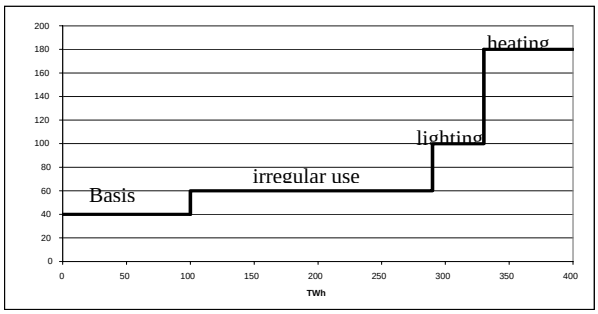
## 1. 6 Environmental issues

Electricity, and more generally energy, production generates some **environmental damages**. France tries to reduce them as much as possible in view of its politics of sustainable development. When electricity is produced, one has, on one hand waste, which if they are properly managed, do not create pollution and, on the other hand, some pollution due to the emission of various pollutants in the environment. A main point concerns **$CO_2$ emissions**, which are responsible of an increase of the greenhouse effect.

With hydraulic and nuclear power, France does not emit $CO_2$ in the atmosphere while running these plants. However, with coal plants, which are started during peak periods, $CO_2$ and other pollutants are emitted (dusts, $SO_2$, $NO_x$). Gas plants, like for example GTCC (Gas Turbines Combined Cycles), are much better in this respect.

The **average emissions of $CO_2$** are 6.2 t/year/inhabitant. On this amount, 1.7t are coming from energy production. The total amount of $CO_2$ emissions for France is 369 Mt from which 105Mt arise from energy production (11% of European emissions). Nevertheless, France is still one of the most efficient industrialized countries as far as greenhouse gases are concerned ($7^{th}$/30 for $CO_2$/population and $4^{th}$/30 for $CO_2$/GDP in OECD).
**The green house gas** (GHG) emissions, all sectors included, amounts to 557 Mte$CO_2$, which represents 3% of European emissions, but there is a light trend to decrease since ten years. Transport and industry are the main sectors responsible for these emissions. The energy sector represents only 16% and decreases continuously. The **Climate Plan** that we shall detail in part 4 should improve the situation.

Due to peak thermal plants, France emits about **70g of $CO_2$ /kWh$_e$**. This is below European emissions, which are, in average, about 340g$CO_2$/kWh$_e$. The nature of the pollution depends on the production unit used, on the technology and on the temperature variations. Typically, coal plant produces about 900g$CO_2$/kWh$_e$.




$CO_2$ emissions by use

We can see in the figure the sharing out of $CO_2$ emissions among the different uses, and the high level of pollution due to heating (180g$CO_2$/kWh$_e$) and electric light (100g$CO_2$/kWh$_e$). As far as heating is concerned, this

corresponds to electricity directly used heating and to run circulating pumps for fuel and gas heating systems. The consumption of electricity at peak production leads to large $CO_2$ emissions because thermal plants are required.
Hydropower plants and all other renewable energies have a small impact on **natural surroundings**. Dams have an influence on the aquatic environment, but all necessary dispositions are taken, among others for fish spawn, to protect natural surroundings. Moreover, for all new project of power plants, renewable or not, environmental impact studies are systematically made before any implementation.

Nuclear reactors produce **nuclear waste**. The Bataille Act of December 1991 has established three complementary research lines for high activities and long lifetime nuclear waste:

- Separating and transmuting
- Reversible deep geological storage
- Surface packaging and long-term storage

Results are expected for 2006, but there are already scientific solutions. Any choice will depend on the long-term politics adopted by the country.

The French production of **radioactive waste** is about 1kg/year/inhabitant. Most of them are coming from energy production. Among them, 99% have a short or medium lifetime and their activity will have decreased so much, after 300 years, that they will no longer be dangerous as far as radioactivity is concerned. The total annual volume of waste represents between 12 000 $m^3$ and 15 000 $m^3$.
Used nuclear fuels represent 1 100/1 200 t per year. About 70% of them are reprocessed by La Hague plant which has an annual capacity of 1 600 t.
In **used nuclear fuels**, there are 95% of uranium, 1% of plutonium, 4% of fission products, and 0,1% of minor actinides. Only fission products and minor actinides can de considered as final waste, because uranium and plutonium can be reused in fast reactors.
Nowadays, the low and intermediate level waste, which represent 978 000 $m^3$, are stored on two disposals, for a total storage capacity of 1 527 000 $m^3$.
The existing stock of high-level waste is about 1 640 $m^3$.

# 2 / Trends

## 2. 1 Past

During the last 50 years, France has built a lot of plants for electricity production. **After the Second World War**, **hydraulics** represented about 50% of electricity generation. For example, in 1960, 50% of the French electricity was produced with hydraulics. **After the first oil crisis**, France has built all the **nuclear plants** in order to reduce its energetic dependence as much as possible. This has allowed to reduce a lot fossil fuels to produce electricity and reduce $CO_2$ emissions as well. However, for transportation, based mostly on oil, and also for heating, the quantities of imported oil and gas have increased.
As far as renewable energies are concerned, they are dominated by hydraulics for electricity production and by biomass for heat production. Use of other renewable sources is very small.

## 2. 2 Present

The situation is presently steady; the structure of the electricity production is not changing. **Nuclear power plants** provide the **base operation** (8000h), and enable exporting electricity (about 60 TWh/year). **Large hydraulic power**, for which France has developed nearly all of its possible potential (550 installations), is running at full capacity for **base production** (run-of-river installations) and **peak** (3000h/reservoir installations). **Thermal** (fossil fuel) generation is used for **semi base operation** (5000h) and peak. Other renewable energies are in constant development, even if France is late compared to its European neighbors, especially as far as wind and solar energies are concerned. France is also depending on imports for coal (no national production), and for oil and gas (very low production).
Primary and final energy demands are still increasing at low pace.

## 2. 3 Future

The **increasing trend of the demand** will go on because of the increase of the population and of the economic growth. Therefore, France will have to adapt and increase its means of electricity production. For long term projections one has also to include new needs: a possible notable use of electricity in new transport areas (electric or hybrid vehicles), an increase of use of air conditioning and heat pumps, etc. France will have to decide about

**prolongation and renewal of some nuclear plants** that will arrive at the end of their supposed initial life during the next 20 years.
The construction of the first **EPR** in Flamanville will give the opportunity to dispose and study an advanced nuclear technology, before making any decision, and also before the new generation IV reactors. It should be noted that such a reactor has already been ordered by Finland. The **GTCC** (Gas Turbines Combined Cycle) technology will also probably be developed to provide semi base and peak demand. The question is open to whether some of the nuclear reactors may be replaced by gas plants. The main problem in that respect is the evolution of the price of gas, which is unknown, and the emission of $CO_2$ which will increase, making difficult to satisfy the **Kyoto Protocol**. The **energetic mix** evolution towards 2020-2025 will have to be studied taking into account many external factors.
Some more measures in favor of **renewable energies** will have to, and have already, been taken in order to increase their part in the electricity production, with a target of **21% in 2010**, and a final consumption of primary green energy up to 8%. Mini hydraulic, biomass, wind power, waves and tidal power, have large potential, and it would be interesting to develop them.

French policy cannot be easily predicted, particularly concerning renewable energies. That is why two types of scenarios have been made by **RTE** (French transmission system operator) for electricity. The first one, called minimal, only takes the production unit which will be certainly used, the second one, called ENR (Renewable Energies), includes production units which are likely to be built, like wind power plants. They represent the low and the high scenarios.

| | | 2006 | 2010 | | 2015 | | | |
|---|---|---|---|---|---|---|---|---|
| | | | minimal | *ENR* | minimal | *ENR* | minimal 15/06 (%) | *ENR 15/06 (%)* |
| Production (TWh) | Nuclear | *422* | 425 | *422* | 427 | *422* | 0,1 | *0,0* |
| | Hydro | 67 | 66 | *66* | 64 | *64* | -0,5 | *-0,5* |
| | Coal | 31 | 39 | *31* | 35 | *29* | 1,4 | *-0,7* |
| | Fuel | 2,2 | 6,1 | *1,7* | 12 | *3,8* | 20,7 | *6,3* |
| | Wind | 0,3 | 0,3 | *27* | 0,3 | *37* | 0,0 | *70,7* |
| | Others | 34 | 34 | *44* | 34 | *47* | 0,0 | *3,7* |
| | Unit needed (GW) | 0 | 3 | *0* | 8,1 | *3,7* | | |
| Consumption (TWh) | Interior | 477 | 504 | *504* | 527 | *527* | 1,1 | *1,1* |
| | Export | 73 | 61 | *81* | 40 | *70* | -6,5 | *-0,5* |
| **Total (TWh)** | | **556** | **571** | ***591*** | **573** | ***603*** | **0,3** | ***0,9*** |

RTE's scenarios for electricity projection for 2015

The last columns are made up percentage.

# 3 / Results of energy studies

Published in 2003, and presented by the French Industry Minister, Mme Nicole Fontaine, the "**Livre Blanc des Energies**" (White Book of Energies) identifies four aims for the French energetic policy.
This policy should be able:

- To guarantee an **access to energy** for all citizens, at competitive price, anywhere in France
- To contribute to the economic **competitiveness** of the country
- To preserve the **energetic security supply**
- To preserve the **environment**.

Energetic policy will have to face two major **challenges** during the two next decades:

- The **Green house Gas** emissions, due for 2/3 to $CO_2$ released in the atmosphere, by extensively using fossil fuels
- The **limitation of oil** (oil peak) and gas production, leading to an increase of theirs prices. Indeed we shall reach the maximum oil production within one or a few decades.

To face these problems, three **action lines**, on a period going from 2003 to 2020, are proposed:

- Boosting **energetic efficiency** and **saving**
- **Diversifying** the energetic sources, with an increased contribution of renewable energies
- Maintaining **all energetic options opened**, and exploring new tracks like using low temperature heat sources.

Concerning **mastering energy and savings**, the aim is, towards 2015, to try to disconnect more the relationship between growth and increase of energy consumption.
For ordinary consumers, the aim is to give better information and education about energy with possibly introducing certificates for energetic performance for houses, labels on domestic electrical appliances, subsidies for investment in equipments saving energy…

For professionals, a regulation will be made to require a minimal energetic performance for new buildings, and to draw up a long-term plan for towns and architecture policy. In parallel, market instruments, like saving energy certificates or $CO_2$ licenses will help in that respect. Public authorities are expected to show the example behavior on this point.
The second action is in line with the European directive whose goal is to produce **21% of the consumption of electricity with renewable energies**. For example, the contribution to thermal energy of wood and sun should have a 50% increase by 2015. This will be supported using taxes, financial aids and feasibility study for new buildings. Researches will be devoted to transportation, costs of renewable energies, waste, hydrogen, etc...

French government has recently launched some long-term energy studies, in order to understand how French $CO_2$ emissions may be cut by a significant factor (3 or 4) in 2050, vs. 2000's emissions. The first study has been presented in march 2004 on behalf of the French Environment Minister. According to this study, the key political decisions (no other option) are simultaneously to **increase the final energy efficiency**, both acting on technical systems and behaviours, to **develop a new politics on transport** (smaller vehicles, more public transports…), and to **increase the renewable energy production**. Open questions and options concern electricity storage, carbon sequestration, hydrogen, nuclear vs. renewables, and natural gas vs. oil and coal. A second study, launched in 2004 by the **DGEMP** (Economy and Industry Ministry), will present **2050 energy scenarios**, based on prospective energy models. A preliminary result, using MEDEE and POLES energy models (ENERDATA and LEPII, Grenoble) has been published in February 2005: it mainly shows that the model can cope with such a "not business as usual" factor 4 objective, and that electricity may play an increasing role in transportation sector.

# 4 / Policy (energy, electricity and environment)

## 4. 1 Present

Energetic policy is of great concern in France. It involves many aspects but is basically based on three points:

- **Security supply**
- **Competitiveness** of French economy, faced with new energy markets, and with unequal repartition of resources in the world
- Reduction of costs and negative impacts on the **environment**

It should also cope with two concerns, at the **social level**:

- Employment and solidarity
- Mission of public utility for electricity: access to electricity for everybody, liability, tariff balancing out…

Concerning more specifically electricity, the French strategic policy is oriented on nuclear energy since the 1970's with the aim to maintain the energetic independence of France and produce electricity at low cost. Hydropower is also largely involved in this politics. Thermal plants are used to a less extent because of costs and $CO_2$ emissions. Renewable energies have to be developed, as mentioned in part 3. **Purchase obligations** by EDF and **invitations to tender** have been introduced since 2000, to push their development.

**Environmental concerns**, and especially green house gases (GHG), are predominant. The **Climate Plan 2004**, with a roadmap until 2010, would allow France to satisfy its Kyoto objectives of GHG emissions reduction. It is updated every two years. The aim is to **stabilize** the French emissions **at the 1990 level**, and even less, to reduce total emissions by 2010 to about 72.3Mteq$CO_2$. Without the Climate Plan, the total GHG emissions would be expected to increase to 9.6% by 2010. The Plan intensifies the measures for all sectors, and prepares France to necessary long-term fundamental changes to preserve climate within a **sustainable development**, in 8 points:

- National campaign on climate change, and on the adaptations of behavior that are required. The **ADEME**, a governmental institution for control of energy and environment, is running this campaign for saving energy, using all medias, to make the public aware.
- Sustainable transports: information about consumption, speed, incentive to use urban collective transports, biofuels…
- Eco-habitat: promotion of bio-climatic concept
- Industry, energy and waste: reducing emissions, quotas markets, controlling energetic demand by saving energy certificates allowance, labels, developing research and use of renewable energies, reducing and recycling waste
- Sustainable agriculture and forests: developing the energetic valorization of biomass, including wood in buildings, coaching agricultural practices
- Sustainable air conditioning: promoting limited and rational use, in transports, residential and tertiary refrigeration sector

- Exemplary behavior of public authorities: necessary mobilization, responsible purchases…
- Research and prospective: creation of a Climate Foundation.

## 4. 2 Future

The **Project of Energy Orientation Law** aims at reducing the dependence of French economy on oil, dividing by four before 2050 (that is to say -3% per year) the GHG emissions, and guarantying a competitive price of energy. This would be possible by:

- Boosting nuclear energy,
- Saving energy: the purpose is to reach a steady final energy intensity decreasing annual rate **of** 2% in 2015, and 2.5% before 2030. The tools to do that are the creation of a cap and trade system on final energy efficiency, the intensification of technical norms in buildings, and an increased part of biofuels going from 2% to 5.7% by 2010.
- Promoting renewable energies: produce 21% of electricity from renewable energies before 2010, and develop thermal energy from renewables.

The nuclear option is maintained opened by 2020, through the **Investment Multi Annual Plan** (PPI) for electric production, made by RTE, the French transmission system operator, and researches on generation IV reactors.

## 4. 3 Critical review

Some comments can be made about French policy, notably about the diversification of power plants and the place of renewable energies in the French system.

French capacities are **little diversified**, but except with hydraulics, it is not possible to produce shortly large quantities of electricity. Most part of the electricity comes from nuclear power, which ensures a low price, stable in time and avoid GHG emissions. As a consequence, France is one of the **less polluting countries** to produce electricity as far as $CO_2$ emissions are concerned. Nuclear power gives also to France a high level of energetic independence. But on the other hand, nuclear plants are mainly concerned with basic electricity production and cannot satisfy peak requirements.
Moreover, the **standardization of the nuclear park** includes that if there is a generic default on one reactor, we have some chance to get it on all the others. This explains why security problems are taken very seriously in France, at a level well above what would be necessary. Perhaps, it should be better in this case to have several families of reactors, to limit this technical risk. But the standardization has enabled to build the French nuclear park very quickly (58 reactors in 20 years, 42 of which in the 10 first years), to lower the costs and to keep a high expertise in this domain

Although there is not a large quantity of **uranium** in the French soil, France monitors all nuclear sectors from the uranium enrichment to the reprocessing of waste and their management. This has allowed a decrease of combustible cost and an increase of supply security. It is a major advantage for France compared to other countries operating nuclear plants.

**Hydropower** enables a large production of electricity with almost no green house gas emission. It gives a lot of flexibility to the French electricity production system allowing to produce electricity on a very short time scale and to store the excess of energy produced by nuclear plants during the off-peak periods. But its production (run-of-river installations) depends on hydrometry (72 TWh in 2000, 64.5 TWh in 2004), which can be hardly predicted.

**Thermal plants** are necessary, in spite of their high level of pollution and cost, because they give flexibility to the system and allow to balance the electricity network. Today, coal stations are in use but they can be replaced by fuel or gas plants, less polluting.
Concerning **renewable energies**, some factors play against them. Consumers want electricity at anytime and any weather condition, so intermittent energies, like wind and solar, are penalized. Moreover, the **tariff balancing out**, which does not show real costs of electricity generation and transport, is such that in some places, where the real price is higher than the price, which is billed, it plays against renewable energies. In this way, even if renewable global costs could be attractive in places, connections to the grid are favored, to beneficiate to the tariff balancing out.
In France, **wind power** has not really environmental benefits although France has relatively favored windy places. This is because one always needs to associate a thermal plant (a gas one to reduce pollution) to windmills in order to get electricity when there is no or not enough wind. Therefore, there are GHG emissions during the time thermal plants are run, i.e. around 70% of the time. Consequently, compared to a nuclear reactor, which does not emit GHG, a set composed of windmills and thermal plants would emit a lot of $CO_2$. In a country where a lot of coal

plants are installed, the use of windmills would be, on the contrary, very useful because one would avoid GHG during about 30% of the time.

# 5 / Peculiarities

The first peculiarity of France is the large **predominance of nuclear** over electricity generation. Hydropower and nuclear power produce about 90% of the total electricity of the country. The French park is the first in Europe, and the second in the world after USA: 58 reactors for 63 GW (34 REP 900 MWe, 20 REP 1 300 MWe, 4 REP 1 450 MWe). In addition, France is going to build the first EPR 1 600 MWe (European Pressurized Reactor) in Flamanville, in order to prepare the future.

The second point concerns the **deregulation of French electric market**.
It began on February 2000, with 30% of market, and will be achieved on July 2007, with total opening for all domestic consumers. Today, all professional consumers can choose theirs producers. With **295 GWh** opened to competition, the French market is the third in E.U. in volume, after Germany and United Kingdom. Between 2000 and 2004, the volume share of challenger has gone from 5% to 21%. **Powernext**, the French Electricity Stock Exchange was born in 2001 to create a price reference in French market, for spot and futures segments. To control the accessibility to the market and the grid (electric and gas), France has created the **CRE** (Energy Regulation Commission), which attends to the well running of the market and the independence of the transmission operator.

Third, concerning **green electricity**, the certificates system has been introduced in 2003. Observ'ER, energies observation institute, is managing the **RECS** (Renewable Energy Certificate System) plan in France. Each certificate equals 1 green MWh. It is unique and is destroyed when it is used. The specificity of the French system is that the certificate includes information about the place and the nature of electricity production, thus enabling its traceability to consumers. In March 2005, about 595 000 certificates have been issued, and **913 MW** capacities have been recorded.

Fourth**, the cap and trade system on energy efficiency**, the white certificates system, that is innovative in Europe (there is such a system in New South Wales in Australia). This system will probably be launched within a few weeks. Basically, every energy supplier (excluding fuels for transportation) will have a given amount of final energy savings to do. On the other hand, every company that engages a "not business as usual" energy efficiency action may have this action certificated (i.e. the amount of avoided energy is validated by a public organism), and this certificate may be sold on a dedicated market. The "obliged" energy suppliers can both engage their own energy efficiency actions, or buy certificates, in order to comply with their obligations.

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