# France
# (July 2010)

# 1. GENERAL INFORMATION

## 1.1. Country Overview

### 1.1.1. Geography and Climate

France is situated in Western Europe and is nearly hexagonal in shape, with an extreme length from north to south of 965 km and a maximum width of 935 km. The total area of metropolitan France, including the island of Corsica in the Mediterranean, is 552 000 $km^2$. In addition to the European or metropolitan territory, the country includes several overseas "*départements*", territorial "*collectivités*", and overseas territories. The climate of metropolitan France is temperate, with wide regional contrasts. The average annual temperature is about 12 degrees. Precipitation is evenly distributed, averaging about 760 mm annually.

### 1.1.2. Population

The total population is about 64,7 million at the beginning of 2010 and the population density around 99 inhabitants per $km^2$ (Table 1). Population growth rate is around 0.7% per annum.

## TABLE 1: POPULATION INFORMATION

| | 1990 | 2000 | 2005 | 2010* | Average Annual Growth Rate (%) 2000 - 2010 |
|---|---|---|---|---|---|
| ***Population (Millions)*** | 58.0 | 60.5 | 62.7 | 64.7 | 0.7 |
| ***Population Density (Inhabitants/km$^2$)*** | - | - | 99.0 | 99.0 | 0.0 |
| ***Urban Population as % of Total*** | - | - | 77.0 | 77.0 | 0.0 |
| ***Mainland Area (1000 km$^2$)*** | | | | | |
| ***Area (1000 km$^2$)*** | - | - | 649.0 | 649.0 | 0.0 |

Source: INSEE, data for 1st of January, (p) for provisory
*: Without population of French Overseas Territories (Polynésie française, Nouvelle-Calédonie, Mayotte, Saint- Pierre-et-Miquelon, Wallis-et-Futuna, Saint-Martin et Saint-Barthélemy) estimated to 0,77 millions inhabitants at 1st of January 2009.

In 2009, the population has increased by 0,35 million of people. Average life expectation is 77,8 years old for men and 84,5 years old for women. The French population represents about 13% of the European Union one, second behind Germany. France (like Ireland) has a dynamic rate of fertility compared to other European countries: (199 children for 100 women) far from the European average (150 children for 100 women). By 2050, according to an INSEE study (Institut National de la Statistique et des Etudes Economiques), the population may reach 70 millions.

### 1.1.3. Economic Data

GDP growth rates in France in the recent years, was 2,2% in 2007 and 0,4% in 2008 too (in constant prices). Table 2 shows the historical trend of Gross Domestic Product (GDP) in current prices.

**TABLE 2: GROSS DOMESTIC PRODUCT**

| | 1980 | 1990 | 2000 | 2006 | 2007 | 2008 | Average Annual Growth Rate (%) 2000 - 2008 |
|---|---|---|---|---|---|---|---|
| ***GDP (Billions of Current €)*** | 445.0 | 1033.0 | 1441.0 | 1806.0 | 1894.0 | 1950.0 | 4.0 |
| ***GDP (Billions of Constant 2000 US$)*** | 689.0 | 1239.0 | 1328.0 | 12953.0 | 2072.0 | 2122.0 | 7.0 |
| ***GDP Per Capita (Current US$/Capita)*** | 11535.0 | 17277.0 | 25276.0 | 30819.0 | 32495.0 | 33090.0 | 3.4 |

Source: INSEE for GDP in current €; OECD for GDP in current US$

## 1.2. Energy Situation

France has deposits of various metals and little fossil fuel resources. Owing to high recovery costs, production of fossil fuels has decreased to a rather low level and is not expected to provide a significant share of the country energy supply in the future. Most hydropower resources are already exploited. Therefore, the French energy policy places high emphasis on improving energy independence through the development of domestic technologies, including nuclear power, alternative energies and renewables, in order to alleviate the country vulnerability to the volatility of fossil fuel international markets and to meet the Kyoto commitments.

The French domestic energy reserves are listed in Table 3. Table 4 provides statistical data on energy and electricity supply and demand between 1973 and 2008. It illustrates the long term increase of nuclear power in primary electricity production to improve French energy independence. Since 1973, primary energy consumption undergoes a regular increase though much slighter in recent years (+0,2% between 2000 and 2008). Domestic production accounts for some 50% of that consumption. The energy balance improved in the last two decades, mainly due to the raise of electricity exports. Energy intensity has lowered owing to structural changes in the economy, i.e. reduction in the share of energy intensive industries in total GDP, and to a lesser extent, to efficiency improvements.

**TABLE 3: ESTIMATED AVAILABLE ENERGY RESOURCES**

| | ***Fossil Fuels*** | | | ***Nuclear*** |
|---|---|---|---|---|
| | **Oil** | **Liquified Hydrocarbons** | **Gas** | **Uranium*** |
| ***Total Amount in Specific Units**** | 14.0 | 0.16 | 6.3 | 11700.0 |

*Solid, Liquid: Million Tons
Gas: $Gm^3$
Uranium: Metric Tons
Hydro, Renewable: TW

*at 01/01/2006, reasonably assured + inferred resources at a cost below 130$/kg of uranium
Proved reserves at 01/01/2008
Sources: MEEDDM

# TABLE 4: ENERGY STATISTICS [Mtoe]

| ***ENERGY CONSUMPTION**** | **1973** | **1980** | **1990** | **2000** | **2005** | **2007** | **2008** | Average Annual Growth Rate (%) **1973 - 2008** | Average Annual Growth Rate (%) **2000 - 2008** |
|---|---|---|---|---|---|---|---|---|---|
| **TOTAL** | 179.7 | 190.0 | 228.3 | 269.2 | 276.7 | 273.7 | 273.6 | 5.4 | 0.2 |
| **- Coal** | 27.8 | 31.1 | 19.2 | 14.2 | 13.4 | 12.9 | 12.1 | -9.8 | -2.0 |
| **- Oil** | 121.5 | 107.1 | 88.3 | 95.1 | 91.6 | 90.4 | 88.9 | -3.8 | -0.8 |
| **- Natural Gas** | 13.2 | 21.1 | 26.3 | 37.6 | 41.0 | 40.6 | 40.7 | 15.0 | 1.0 |
| **- Primary Electricity** | 7.7 | 22.2 | 83.2 | 108.9 | 117.5 | 116.2 | 117.1 | 40.5 | 0.9 |
| **- Thermal Renewables** | 9.4 | 8.4 | 11.4 | 13.3 | 13.2 | 13.7 | 14.9 | 5.9 | 1.4 |

| ***ENERGY PRODUCTION*** | **1970** | **1980** | **1990** | **2000** | **2005** | **2007** | **2008** | **1973 - 2008** | **2000 - 2008** |
|---|---|---|---|---|---|---|---|---|---|
| **TOTAL** | 43.5 | 52.5 | 111.8 | 132.5 | 138.4 | 135.3 | 137.1 | 15.4 | 0.4 |
| **- Coal** | 17.3 | 13.1 | 7.7 | 2.3 | 0.3 | 0.2 | 0.1 | -47.5 | -32.4 |
| **- Oil** | 2.2 | 2.4 | 3.5 | 1.7 | 1.3 | 1.1 | 1.1 | -8.3 | -6.0 |
| **- Natural Gas** | 6.3 | 6.3 | 2.5 | 1.5 | 0.9 | 0.9 | 0.8 | -22.7 | -7.5 |
| **- Primary Nuclear Electric** | 3.8 | 16.0 | 81.7 | 108.2 | 117.7 | 114.6 | 114.5 | 53.0 | 0.7 |
| **- Other Renewables** | 9.8 | 8.7 | 11.4 | 12.5 | 13.3 | 13.7 | 14.0 | 1.0 | 1.4 |

| ***Energy Independence Rate*** | **1970** | **1980** | **1990** | **2000** | **2005** | **2007** | **2008** | **1973 - 2008** | **2000 - 2008** |
|---|---|---|---|---|---|---|---|---|---|
| **TOTAL** | 23.7 | 27.4 | 49.7 | 50.1 | 50.1 | 50.3 | 50.5 | - | - |

* Latest Available Data

** Energy Consumption = Primary Energy Consumption + Net Import (Import - Export) of Secondary Energy

*** Solid Fuels Include Coal and Ligite

Source: MEEDDM

During the post World War II reconstruction period, France's economic and social development relied mainly on the deployment of energy intensive industries. The rapidly increasing energy needs were partly met by domestic coal and hydropower resources. However, French domestic fossil fuel resources being limited and costly, the country had to rely heavily on imports for its energy supply. By 1973, imports were covering more than 75% of national energy consumption, compared to 38% in 1960. After the 70's oil crisis, the country was in need of better energy independence. At that time, implementation of a large nuclear power program became a major element of France's energy policy, including also energy saving measures, efficiency improvement and research and development in the field of renewable energies. The share of nuclear power in primary energy supply increased from less than 2% in the late seventies to about one third in the mid nineties and reached 41% in 2008.

The main macro-economic impacts of France's energy policy are: drastic improvement in the energy trade balance, stabilization of domestic energy prices at a rather low level, increased competitiveness of French companies on international markets and deployment of a nuclear industry sector covering reactor construction and the whole of the fuel cycle. Increased awareness of environmental constraints reflects in the French energy mix, aiming to reduce the negative impacts of energy production on health and environment. In this regard, substitution of nuclear power to fossil fuel for electricity generation resulted in a drastic reduction of atmospheric emissions.

## 1.3. The Electricity System

### 1.3.1. Decision Making Process

The General Directorate for Energy and Climate (DGEC), under the Ministry of Ecology, Energy, Sustainable Development and Sea (MEEDDM), is in charge of implementing the French government policy on energy within the framework of the European directives. The Minister of MEEDDM and the Minister for Health control health and environmental impacts of industrial facilities, including energy production and transformation plants.

The transmission grid operator RTE (Réseau de Transport de l'Electricité) is in charge of balancing generation and consumption over the grid, operating the power system, and maintaining and developing the public power transmission network. According to the law of 10 February 2000, RTE must establish at least every two years an evaluation of medium-term evolution of consumption, transport capacities, distribution, and exchanges with foreign grids, to help the government to elaborate the PPI (*Programmation Pluriannuelle des Investissements)* which is a report on medium-term power generation capacity investments planning that the energy Ministry must prepare and release to the Parliament. Last report on PPI was released in June 2009.

The state-owned utility *Electricité de France* (EDF) which was nationalized in 1946 along with the national coal, oil and gas companies, became a limited liability company in November 2004 and increased its capital by 30% in October 2005 (the law stipulates that the French State will hold at least 70% of the capital and voting rights in EDF SA). A public service contract between the government and EDF, laying down the terms and conditions for the implementation of its public service mission, was also signed at the same time. The French government appoints EDF's chairman.

### 1.3.2. Structure of the Electricity Sector

The European directives on the liberalization of the electricity market have been fully transposed into the French legislation.

The transmission grid operator RTE has been individualized inside EDF according to the European rules, and manages the load dispatch system independently. An independent regulatory authority, CRE *(Commission de Régulation de l'Energie)*, guarantees equal access and competition to all market players. Since July 2007, any site (34 million sites) can choose to be supplied by a private utility or remain within regulated tariff (three possible contracts).

EDF is still the main operator for production and distribution. It operates all nuclear and part of the fossil-fuel fired and hydro-power plants. The main other suppliers are GDF-Suez (both companies merged in July 2008 and hold CNR and SHEM ), SNET *(*groupe *EON)* for coal-fired plants and Wind electricity, and private manufacturers operating back-up or combined heat and power production units, as well as operators of small and medium size hydropower plants. 17 providers recorded on the CRE's suppliers' list actually operate on the French market.

Regarding distribution activities, local authorities grant the concession of well-defined areas. There are about 160 distribution companies featuring municipality or joint ownership, with a 5% share of total electricity billing.

### 1.3.3. Main Indicators

Table 5 shows the history of electricity production and Table 6 the energy related ratios. At present, about 90% of France’s electricity is of nuclear and renewable origin, the remaining 10% coming mainly from fossil fuels. Electricity demand grows in line with GDP, though at lower rate.

## TABLE 5: ELECTRICITY PRODUCTION, CONSUMPTION & CAPACITY

| *Capacity of Electrical Plants [GWe]* | 1973 | 1979 | 1990 | 2000 | 2005 | 2007 | 2008 | Average Annual Growth Rate (%) 1973 - 2008 | Average Annual Growth Rate (%) 2000 - 2008 |
|---|---|---|---|---|---|---|---|---|---|
| **TOTAL** | - | - | 103.7 | 115.1 | 115.5 | 115.9 | 120.2 | 0.8 | **0.1** |
| **- Thermal** | - | - | 23 | 26.7 | 25.3 | 24.1 | 26.2 | 0.7 | -0.2 |
| **- Hydro** | - | - | 25 | 25.2 | 25.4 | 25.4 | 25.3 | 0.1 | 0 |
| **- Nuclear** | - | - | 55.8 | 63.2 | 63.3 | 63.3 | 63.1 | 0.7 | 0 |
| **- Other Renewables** | - | - | - | - | 1.5 | 3.1 | 5.6 | - | - |
| ***Electricity Production (TWh)*** | **1973** | **1979** | **1990** | **2000** | **2005** | **2007** | **2008** | **1973 - 2008** | **2000 - 2008** |
| **TOTAL**** | 182.4 | 241.4 | 420.1 | 540.8 | 576.2 | 569.9 | 574.5 | 3.3 | 0.7 |
| **- Thermal** | 119.5 | 133.6 | 48.2 | 53.1 | 66.7 | 62 | 60.4 | -1.9 | 1.6 |
| **- Hydro, Wind, Solar** | 48.1 | 67.8 | 58.3 | 72.5 | 58 | 68.3 | 74.7 | 1.2 | 0.4 |
| **- Nuclear** | 14.8 | 40 | 313.7 | 415.2 | 451.5 | 439.7 | 439.5 | 10.2 | 0.7 |

**Electricity transmission losses are not deducted
Source: RTE

## TABLE 6: Energy Related Ratios

| | 1973 | 1979 | 1990 | 2000 | 2005 | 2008 |
|---|---|---|---|---|---|---|
| ***Energy Consumption Per Capita (TEP/Capita)*** | 3.5 | 3.5 | 3.9 | 4.3 | 4.4 | 4.15 |
| ***Electricity Consumption Per Capita (MWh/Capita)*** | 3.4 | 4.5 | 6.5 | 7.8 | 8.2 | 7.6 |
| ***Electricity Production/Energy Production (%)*** | 18 | 34 | 78 | 86 | 89 | 88 |
| ***Nuclear/Total Electricity (%)*** | 8 | 17 | 75 | 77 | 78 | 76.3 |
| ***Ratio of External Dependency (%)***** | 76.1 | 75.3 | 50.6 | 48.9 | 50.4 | 43.5 |

**Net Import/Total Energy Consumption
Source: Ministry of Economy

# 2. NUCLEAR POWER SITUATION

## 2.1. Historical Development and current nuclear power organizational structure

### 2.1.1. Overview

Historically, the development of nuclear power fell into four phases. During the 1960's, in line with the overall target of industrial independence and domestic technological development, indigenous designs were promoted (mainly natural uranium - gas cooled reactors and fast breeders). However, a PWR unit (Chooz-A) was built jointly with Belgium and a heavy water reactor in Brittany (Brennilis).

International developments in the nuclear industry led in the late sixties to the recognition that the French reactor designs could not compete with light water reactors. In 1969 the decision was made to build LWRs under license, whilst restructuring the domestic industry to improve competitiveness. Subsequently, the French government envisaged a construction program of one or two PWRs a year.

From 1974 to 1981 emphasis was put on adaptation of the Westinghouse design for the development of a French standard. The nuclear programme accelerated the pace with the 1970's oil crisis. The unit-capacity of French reactors increased from 900 MWe to 1,300 MWe and later to 1,450 MWe. France developed and implemented, in parallel with the nuclear power plant program, a strong domestic fuel cycle industry, built upon the infrastructure originally established by CEA.

In 1981, Framatome terminated its license with Westinghouse and negotiated a new agreement, giving greater autonomy. Framatome developed a wide range of servicing expertise and capabilities in reactor operation and maintenance services. In the same year, France had to adapt its energy policy to a lower than expected economic growth, together with the occurrence of over-capacity in the national electricity supply system. The achievement of the 1450 MWe N4 model was the landmark for a totally autonomous French reactor design.

Then, a new period started. In 2000, Framatome merged with the nuclear activities of Siemens (Germany). It resulted into *Framatome Advanced Nuclear Power*, which is integrated to the AREVA group and now called AREVA NP (Nuclear Plant) since 2005. AREVA holds 66% and Siemens 34%. In 2006, the construction of a 1600 MW European Pressurized Reactor, designed by AREVA NC, was started in Olkiluoto (Finland). It was followed by another one in Flamanville (France) in 2007. In January 2009, the French president announced the future construction of a reactor in Penly (France). In February 2009, SIEMENS announced its wish to sell its AREVA group's participation.

### 2.1.2. Current Organizational Chart(s)

- Government authorities :
  - DGEC (General Directorate for Energy and Climate),
  - Independent nuclear agency: French Safety Authority (Autorité de Sûreté Nucléaire - ASN)
- Expert institution: IRSN (Radioprotection and Nuclear Safety Institute)

- Research and development: CEA (Atomic Energy Commission)
- Nuclear power plants operator: EDF (Electricité de France)
- Nuclear plants construction : AREVA NP
- Fuel cycle industry, including engineering and services : AREVA group
- Mining : AREVA NC
- Conversion : Comurhex
- Enrichment: Eurodif, Georges Besse II
- Fuel fabrication : AREVA NP (UO), AREVA NC (MOX)
- Reprocessing and packaging: AREVA NC
- Radioactive waste management (R&D and disposal) : ANDRA

## 2.2. Nuclear Power Plants: Status and Operations

The share of nuclear power in the French electricity supply has reached its technical and economic maximum, amounting to about 63,000 MWe. It consists of fifty-eight units pressurized water reactors (thirty four 900 MWe, twenty 1300 MWe, and four 1450's), all constructed by the French manufacturer Framatome (AREVA NP), now that the 230 MWe fast breeder reactor, Phenix has been disconnected from grid in early 2009.

The nuclear plants account for 390 TWh in 2009 (over 75% of total electricity production), setting France the world's second largest nuclear power producer. Table 7 lists the status of the power plants as of year-end 2008. In 2008 Nuclear power generation represented about 42% of total primary energy supply, and 84% of the domestic energy production, making EDF by far the number one nuclear operator and the first electricity producer in the world.

# TABLE 7: STATUS AND PERFORMANCE OF NUCLEAR POWER PLANTS

| Station | Type | Net Capacity | Operator | Status | Reactor Supplier | Construction Date+ | Criticality Date | Grid Date++ | Commercial Date | Shutdown Date | UCF for Year** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BELLEVILLE-1 | PWR | 1310 | EDF | Operational | FRAM | 01-May-80 | 09-Sep-87 | 14-Oct-87 | 01-juin-88 | | 55,3 |
| BELLEVILLE-2 | PWR | 1310 | EDF | Operational | FRAM | 01-Aug-80 | 25-May-88 | 06-juil-88 | 01-janv-89 | | 92,6 |
| BLAYAIS-1 | PWR | 910 | EDF | Operational | FRAM | 01-janv-77 | 20-May-81 | 12-juin-81 | 01-Dec-81 | | 86,1 |
| BLAYAIS-2 | PWR | 910 | EDF | Operational | FRAM | 01-janv-77 | 28-juin-82 | 17-juil-82 | 01-Feb-83 | | 90,3 |
| BLAYAIS-3 | PWR | 910 | EDF | Operational | FRAM | 01-Apr-78 | 29-juil-83 | 17-Aug-83 | 14-Nov-83 | | 87 |
| BLAYAIS-4 | PWR | 910 | EDF | Operational | FRAM | 01-Apr-78 | 01-May-83 | 16-May-83 | 01-Oct-83 | | 87,4 |
| BUGEY-2 | PWR | 910 | EDF | Operational | FRAM | 01-Nov-72 | 20-Apr-78 | 10-May-78 | 01-mars-79 | | 78,9 |
| BUGEY-3 | PWR | 910 | EDF | Operational | FRAM | 01-Sep-73 | 31-Aug-78 | 21-Sep-78 | 01-mars-79 | | 73,5 |
| BUGEY-4 | PWR | 880 | EDF | Operational | FRAM | 01-juin-74 | 17-Feb-79 | 08-mars-79 | 01-juil-79 | | 88,5 |
| BUGEY-5 | PWR | 880 | EDF | Operational | FRAM | 01-juil-74 | 15-juil-79 | 31-juil-79 | 03-janv-80 | | 87 |
| CATTENOM-1 | PWR | 1300 | EDF | Operational | FRAM | 29-Oct-79 | 24-Oct-86 | 13-Nov-86 | 01-Apr-87 | | 82,2 |
| CATTENOM-2 | PWR | 1300 | EDF | Operational | FRAM | 28-juil-80 | 07-Aug-87 | 17-Sep-87 | 01-Feb-88 | | 71,7 |
| CATTENOM-3 | PWR | 1300 | EDF | Operational | FRAM | 15-juin-82 | 16-Feb-90 | 06-juil-90 | 01-Feb-91 | | 80,5 |
| CATTENOM-4 | PWR | 1300 | EDF | Operational | FRAM | 28-Sep-83 | 04-May-91 | 27-May-91 | 01-janv-92 | | 89,8 |
| CHINON-B-1 | PWR | 905 | EDF | Operational | FRAM | 01-mars-77 | 28-Oct-82 | 30-Nov-82 | 01-Feb-84 | | 88,1 |
| CHINON-B-2 | PWR | 905 | EDF | Operational | FRAM | 01-mars-77 | 23-Sep-83 | 29-Nov-83 | 01-Aug-84 | | 65 |
| CHINON-B-3 | PWR | 905 | EDF | Operational | FRAM | 01-Oct-80 | 18-Sep-86 | 20-Oct-86 | 04-mars-87 | | 83,5 |
| CHINON-B-4 | PWR | 905 | EDF | Operational | FRAM | 01-Feb-81 | 13-Oct-87 | 14-Nov-87 | 01-Apr-88 | | 77,1 |
| CHOOZ-B-1 | PWR | 1500 | EDF | Operational | FRAM | 01-janv-84 | 25-juil-96 | 30-Aug-96 | 15-May-00 | | 97 |
| CHOOZ-B-2 | PWR | 1500 | EDF | Operational | FRAM | 31-Dec-85 | 10-mars-97 | 09-Apr-97 | 29-Sep-00 | | 86,1 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CIVAUX-1 | PWR | 1495 | EDF | Operational | FRAM | 15-Oct-88 | 29-Nov-97 | 24-Dec-97 | 28-janv-02 | | 77 |
| CIVAUX-2 | PWR | 1495 | EDF | Operational | FRAM | 01-Apr-91 | 27-Nov-99 | 24-Dec-99 | 23-Apr-02 | | 91,1 |
| CRUAS-1 | PWR | 915 | EDF | Operational | FRAM | 01-Aug-78 | 02-Apr-83 | 29-Apr-83 | 02-Apr-84 | | 80,8 |
| CRUAS-2 | PWR | 915 | EDF | Operational | FRAM | 15-Nov-78 | 01-Aug-84 | 06-Sep-84 | 01-Apr-85 | | 70,9 |
| CRUAS-3 | PWR | 915 | EDF | Operational | FRAM | 15-Apr-79 | 09-Apr-84 | 14-May-84 | 10-Sep-84 | | 61 |
| CRUAS-4 | PWR | 915 | EDF | Operational | FRAM | 01-Oct-79 | 01-Oct-84 | 27-Oct-84 | 11-Feb-85 | | 78,5 |
| DAMPIERRE-1 | PWR | 890 | EDF | Operational | FRAM | 01-Feb-75 | 15-mars-80 | 23-mars-80 | 10-Sep-80 | | 90,7 |
| DAMPIERRE-2 | PWR | 890 | EDF | Operational | FRAM | 01-Apr-75 | 05-Dec-80 | 10-Dec-80 | 16-Feb-81 | | |
| DAMPIERRE-3 | PWR | 890 | EDF | Operational | FRAM | 01-Sep-75 | 25-janv-81 | 30-janv-81 | 27-May-81 | | 91,5 |
| DAMPIERRE-4 | PWR | 890 | EDF | Operational | FRAM | 01-Dec-75 | 05-Aug-81 | 18-Aug-81 | 20-Nov-81 | | 68,8 |
| FESSENHEIM-1 | PWR | 880 | EDF | Operational | FRAM | 01-Sep-71 | 07-mars-77 | 06-Apr-77 | 30-Dec-77 | | 67,9 |
| FESSENHEIM-2 | PWR | 880 | EDF | Operational | FRAM | 01-Feb-72 | 27-juin-77 | 07-Oct-77 | 18-mars-78 | | 68,5 |
| FLAMANVILLE-1 | PWR | 1330 | EDF | Operational | FRAM | 01-Dec-79 | 29-Sep-85 | 04-Dec-85 | 01-Dec-86 | | 43,8 |
| FLAMANVILLE-2 | PWR | 1330 | EDF | Operational | FRAM | 01-May-80 | 12-juin-86 | 18-juil-86 | 09-mars-87 | | 57,9 |
| FLAMANVILLE-3 | PWR | 1600 | EDF | construction | AREVA | 07-Dec | - | - | - | | - |
| GOLFECH-1 | PWR | 1310 | EDF | Operational | FRAM | 17-Nov-82 | 24-Apr-90 | 07-juin-90 | 01-Feb-91 | | 80 |
| GOLFECH-2 | PWR | 1310 | EDF | Operational | FRAM | 01-Oct-84 | 21-May-93 | 18-juin-93 | 01-janv-94 | | 79,2 |
| GRAVELINES-1 | PWR | 910 | EDF | Operational | FRAM | 01-Feb-75 | 21-Feb-80 | 13-mars-80 | 01-Dec-80 | | 91,8 |
| GRAVELINES-2 | PWR | 910 | EDF | Operational | FRAM | 01-mars-75 | 02-Aug-80 | 26-Aug-80 | 01-Dec-80 | | 80,7 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| GRAVELINES-3 | PWR | 910 | EDF | Operational | FRAM | 01-Dec-75 | 30-Nov-80 | 12-Dec-80 | 01-juin-81 | | 78,6 |
| GRAVELINES-4 | PWR | 910 | EDF | Operational | FRAM | 01-Apr-76 | 31-May-81 | 14-juin-81 | 01-Oct-81 | | 85,8 |
| GRAVELINES-5 | PWR | 910 | EDF | Operational | FRAM | 01-Oct-79 | 05-Aug-84 | 28-Aug-84 | 15-janv-85 | | 82,3 |
| GRAVELINES-6 | PWR | 910 | EDF | Operational | FRAM | 01-Oct-79 | 21-juil-85 | 01-Aug-85 | 25-Oct-85 | | 71,5 |
| NOGENT-1 | PWR | 1310 | EDF | Operational | FRAM | 26-May-81 | 12-Sep-87 | 21-Oct-87 | 24-Feb-88 | | 78 |
| NOGENT-2 | PWR | 1310 | EDF | Operational | FRAM | 01-janv-82 | 04-Oct-88 | 14-Dec-88 | 01-May-89 | | 68,8 |
| PALUEL-1 | PWR | 1330 | EDF | Operational | FRAM | 15-Aug-77 | 13-May-84 | 22-juin-84 | 01-Dec-85 | | 91,1 |
| PALUEL-2 | PWR | 1330 | EDF | Operational | FRAM | 01-janv-78 | 11-Aug-84 | 14-Sep-84 | 01-Dec-85 | | 85,1 |
| PALUEL-3 | PWR | 1330 | EDF | Operational | FRAM | 01-Feb-79 | 07-Aug-85 | 30-Sep-85 | 01-Feb-86 | | 98 |
| PALUEL-4 | PWR | 1330 | EDF | Operational | FRAM | 01-Feb-80 | 29-mars-86 | 11-Apr-86 | 01-juin-86 | | 70,8 |
| PENLY-1 | PWR | 1330 | EDF | Operational | FRAM | 01-Sep-82 | 01-Apr-90 | 04-May-90 | 01-Dec-90 | | 95,5 |
| PENLY-2 | PWR | 1330 | EDF | Operational | FRAM | 01-Aug-84 | 10-janv-92 | 01-Feb-92 | 01-Nov-92 | | 86,1 |
| ST. ALBAN-1 | PWR | 1335 | EDF | Operational | FRAM | 29-janv-79 | 04-Aug-85 | 30-Aug-85 | 01-May-86 | | 49,3 |
| ST. ALBAN-2 | PWR | 1335 | EDF | Operational | FRAM | 31-juil-79 | 07-juin-86 | 03-juil-86 | 01-mars-87 | | 58,1 |
| ST. LAURENT-B-1 | PWR | 915 | EDF | Operational | FRAM | 01-May-76 | 04-janv-81 | 21-janv-81 | 01-Aug-83 | | 90,8 |
| ST. LAURENT-B-2 | PWR | 915 | EDF | Operational | FRAM | 01-juil-76 | 12-May-81 | 01-juin-81 | 01-Aug-83 | | 88 |
| TRICASTIN-1 | PWR | 915 | EDF | Operational | FRAM | 01-Nov-74 | 21-Feb-80 | 31-May-80 | 01-Dec-80 | | 89,7 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TRICASTIN-2 | PWR | 915 | EDF | Operational | FRAM | 01-Dec-74 | 22-juil-80 | 07-Aug-80 | 01-Dec-80 | | 65,1 |
| TRICASTIN-3 | PWR | 915 | EDF | Operational | FRAM | 01-Apr-75 | 29-Nov-80 | 10-Feb-81 | 11-May-81 | | 79,7 |
| TRICASTIN-4 | PWR | 915 | EDF | Operational | FRAM | 01-May-75 | 31-May-81 | 12-juin-81 | 01-Nov-81 | | 77,4 |
| BUGEY-1 | GCR | 540 | EDF | Shut Down | VARIOUS | 01-Dec-65 | 21-mars-72 | 15-Apr-72 | 01-juil-72 | | 34481 |
| CHINON-A1 | GCR | 70 | EDF | Shut Down | LEVIVIER | 01-Feb-57 | 16-Sep-62 | 14-juin-63 | 01-Feb-64 | | 26770 |
| CHINON-A2 | GCR | 210 | EDF | Shut Down | LEVIVIER | 01-Aug-59 | 17-Aug-64 | 24-Feb-65 | 24-Feb-65 | 14-juin-85 | |
| CHINON-A3 | GCR | 480 | EDF | Shut Down | GTM | 01-mars-61 | 01-mars-66 | 04-Aug-66 | 04-Aug-66 | 15-juin-90 | |
| CHOOZ-A(ARDENNES) | PWR | 310 | SENA | Shut Down | A/F/W | 01-janv-62 | 18-Oct-66 | 03-Apr-67 | 15-Apr-67 | | 33541 |
| CREYS-MALVILLE | FBR | 1200 | NERSA | Shut Down | ASPALDO | 13-Dec-76 | 07-Sep-85 | 14-janv-86 | | | 36160 |
| EL-4 (MONTS D'ARREE) | HWGCR | 70 | EDF | Shut Down | GAAA | 01-juil-62 | 23-Dec-66 | 09-juil-67 | 01-juin-68 | 31-juil-85 | |
| G-2 (MARCOULE) | GCR | 38 | COGEMA | Shut Down | SACM | 01-mars-55 | 21-juil-58 | 22-Apr-59 | 22-Apr-59 | | 29253 |
| G-3 (MARCOULE) | GCR | 38 | COGEMA | Shut Down | SACM | 01-mars-56 | 11-juin-59 | 04-Apr-60 | 04-Apr-60 | 20-juin-84 | |
| PHENIX | FBR | 233 | CEA/EDF | Disconnected/ to be shutdown | CNCLNEY | 01-Nov-68 | 26907 | 13-Dec-73 | 14-juil-74 | | |
| ST. LAURENT-A1 | GCR | 480 | EDF | Shut Down | VARIOUS | 01-Oct-63 | 07-janv-69 | 14-mars-69 | 01-juin-69 | | 32981 |
| ST. LAURENT-A2 | GCR | 515 | EDF | Shut Down | VARIOUS | 01-janv-66 | 04-juil-71 | 09-Aug-71 | 01-Nov-71 | | 33751 |

Source: EDF and IAEA Power Reactor Information System.

## 2.3. Supply of NPPs

The leading company is AREVA NP (owned at 66% by AREVA and 34% by Siemens). It is associated to AREVA NC and AREVA T&D within AREVA group.

Historically the main companies in the nuclear plant construction industry were Framatome (now AREVA NP), which supplied the nuclear island, and Alstom for the conventional part. After Alcatel withdrawal from Framatome's ownership, the decision was taken in 1999 to transfer most of its shares to Cogema (now AREVA NC) and CEA. In counterpart, Framatome took over Cogema's activities in uranium fuel manufacturing.

## 2.4. Operation of NPPs

The electricity utility *Electricité de France* (EDF) operates all the French nuclear power plants. In 2009, nuclear plants have reached an availability factor of 78%.

## 2.5. Fuel Cycle and Waste Management

AREVA NC (ex COGEMA) controls most of the fuel cycle industry, with the exception of UO-fuel manufacturing (AREVA NP) and of radioactive waste management and disposal, run by the independent public agency ANDRA. AREVA NC is an industrial and commercial leader in all phases of the fuel cycle, including prospection and running of uranium mines, conversion (Comurhex), enrichment (Eurodif, SET), MOX-fuel fabrication (Melox), reprocessing and waste packaging.

## 2.6. Research and Development

In 1945 the French government created a national agency, the *Commissariat à l'Energie Atomique* (CEA; Atomic Energy Commission), for the development of all aspects of atomic energy, including both civil and military applications. Although its responsibilities changed through time, particularly with the transfer of some industrial activities to newly created subsidiaries, CEA has retained most of its early activities and interests in mean and long term R&D, notably in reactor design, fuel concepts, enrichment, waste transmutation and disposal as well as in technology transfer and fundamental research.

- The CEA has joined the GIF (Generation IV International Forum) R&D programme to study promising technologies for future nuclear energy systems, addressing in the first place the issues of enhanced safety, sustainability, non-proliferation and economics, and is committed to realize a "Fourth Generation" prototype by 2020 since a decision of the previous Republic President.

The French R&D program on Future Nuclear Systems in the Generation IV framework is focused on two axes:

- Fast reactor designs with closed fuel cycle to reduce the final waste and make the best use of natural resources. Two designs are especially studied, a gas-cooled fast reactor and a sodium-cooled fast reactor.

- Very High Temperature Reactors (HTR, VHTR) in order to produce hydrogen for future industrial uses and transport.

- French nuclear actors and potential industrial nuclear heat users are involved in the European « Sustainable Nuclear Energy Research » technological platform.

- In June 2005, the site of Cadarache (France) was officially chosen to welcome ITER (International Thermoreactor Experimental Reactor). The construction has started.

- The construction of the new experimental fission reactor (100 MWth) called Jules Horowitz has been started in 2007. It will be used for experiments on nuclear materials and fuels and production of medical radio-isotopes.

### 2.7. International Co-operation and Initiatives

- France is member of several international organizations, including the International Atomic Energy Agency (IAEA), the Nuclear Energy Agency (NEA) of the Organization for Economic Cooperation and Development (OECD). It participates to other bilateral and multilateral organizations such as the World Association of Nuclear Operators with EDF as member.

- France also participates in INPRO, the IAEA project bringing together developers and potential users of future nuclear technologies (or innovative nuclear systems).

- As mentioned above, France is also member of the Generation IV International Forum (GIF), the international collective of 12 countries (+ Euratom) dedicated to the development of the next generation of nuclear reactors and fuel cycle technologies.

- France participates also to GNEP, the partnership of countries aiming to improve the proliferation-resistance of the nuclear fuel cycle while guaranteeing access to fuel supplies

### 2.8. Human resources development

The INSTN (Nuclear Techniques and Sciences National Institute -*Institut National des Sciences et des Techniques Nucléaires*) was created in 1956 by the CEA under the authority of the National Education Ministry and the Industry Ministry. Its main mission is to transmit CEA's know-how. It delivers academic diplomas (e.g. Masters), engineer diplomas, and welcome PhD students. It also offers continuous training. It is certified ISO 2001 and chairs the European Nuclear Education Network (ENEN).

## 3. NATIONAL LAWS AND REGULATIONS

### 3.1. Safety Authority and the Licensing Process

Nuclear legislation in France has developed in successive stages in line with technological advances and growth in the atomic energy field. Therefore, many of the enactments governing nuclear activities are to be found in the general French legislation on environmental protection, water supply, atmospheric pollution, public health and labour.

However, the French Parliament has adopted a number of specific enactments. Examples include Act No. 68-493 (30 October 1968), setting special rules as to third

party liability in the field of nuclear energy, which is distinct from the ordinary French law on third party liability, the 19 July 1952 Act, now embodied in the Public Health Code, specifying licensing requirements for the use of radioisotopes, Act No. 80-572 of 25 July 1980 on the protection and control of nuclear materials, and Act No. 91-1381 on the management of nuclear wastes. In June 2006 was adopted the Act 2006-686 on transparency and safety.

Although French nuclear law is characterized by its variety of sources, as in other countries where nuclear energy has developed, the original features of this legislation derive chiefly from international recommendations or regulations. For example, radiation protection standards are derived from the Recommendations of the International Commission on Radiological Protection (ICRP) and Directives issued by the European Union (formerly the European Community). Likewise, the French Act of 1968 on the liability of nuclear operators is directly derived from the Paris Convention of 29 July 1960.

French nuclear legislation began to develop from the time the Atomic Energy Commission (*Commissariat à l'énergie atomique* - CEA), the public agency set up by the State in 1945 [Ordinance No. 45-2563 of 18 October 1945] and formerly reporting directly to the prime minister, no longer held a monopoly for nuclear activities, in other words from the time nuclear energy applications entered the industrial stage, thus requiring the involvement of new nuclear operators. This development had several landmarks: in 1963, a system for licensing and controlling major nuclear installations was introduced, setting government responsibility in matters of population and occupational safety (Decree of 11 December 1963). Prior to this, procedures concerning the licensing and control of industrial activities were dealt with by the *Préfet* for each *Département*. In 1973, this system was expanded to cover the development of the nuclear power programme, and better define the role of government authorities. Finally, the decree of 20 June 1966 included Euratom Directives as part of the French radiation protection regulations.

In the course of the 1980's, the enactments setting up the CEA were amended so as to strengthen its inter-ministerial status and a tripartite Board of Administration including staff representatives was created. However governmental decisions are prepared by the Atomic Energy Committee, which acts as a restricted inter-ministerial committee on nuclear energy matters. CEA is now answerable to the Minister for Industry, to the Minister for Research [Decrees No. 93-1272 of 1 December 1993 and No. 93-796 of 16 April 1993] and to the Minister of Defense. The main task of CEA was laid down in September 1992 by the Government: concentrate on developing the control of atom uses for purposes of energy, health, defence and industry, while remaining attentive to the requests made by its industrial and research partners. More specifically, the inter-ministerial committee of 1 June 1999 requested CEA to "strengthen long-term research on future reactors capable of reducing, and even eliminate the production of long-lived radio-active waste". In addition CEA was given a particular responsibility for R&D on alternative and renewable energies.

The regulations for large nuclear installations, referred to above, have been supplemented with regard to procedures by an Instruction of 27 March 1973 and a Decision of the same date (amended by a Decision of 17 December 1976), which are internal instruments issued by the Minister for Industry. The authorities primarily involved in the licensing procedure for the setting up of large nuclear installations are the Minister for Industry and the Minister for Ecology and Sustainable Development. For this purpose, the Central Service for Nuclear Installations Safety (SCSIN), set up in 1973 within the Ministry of Industry, had been reshuffled as the Directorate for Nuclear Installations Safety *(Direction de la Sûreté des Installations Nucléaires, DSIN*).

In the beginning of 2002, the DGSNR (General Directorate for Nuclear Safety and Radioprotection) was created as a result of the merger of DSIN and the former Central Board for Protection against Ionizing Radiations (*Office de Protection contre les rayonnements ionisants, OPRI*). As a consequence, in addition to nuclear safety, DGSNR retained also the responsibilities of the former OPRI regarding radioprotection, ie carrying out measurements or analytical work in order to determine the level of radioactivity or ionizing radiation that might become hazardous to health in various environmental situations, for individuals as well as for the population as a whole. It also co-ordinated and defined controls for the radiation protection of workers and was involved in the safety plans to be put in action in case of radioactive incident. DGSNR reported to the Ministers for Industry, Health and Ecology and Sustainable Development. At the local level, DGSNR's actions were relayed through the nuclear divisions of the Regional Directorates for Industry, Research and Environment (DRIRE). These Directorates are in charge of the survey of nuclear installations and monitoring reactor shutdowns and all pressurized components. They also provide technical support to the "*préfet*", the Government local representative, in particular in case of accident.

DGSNR was assisted in decision making by the Institute for Radiation-Protection and Nuclear Safety (*Institut de Radio-Protection et de Sûreté Nucléaire - IRSN*), itself resulting from the merger of the former IPSN (*Institut de Protection et de sûreté nucléaire*) and part of the OPRI (*Office de protection contre les rayonnements ionisants*). The IRSN can also undertake studies or research on protection and nuclear safety problems on request of any concerned ministerial department or agency (Law n°2001-398 AFSSE of 9 May 2001).

In June 2006, the Act 2006-686 on transparency and safety created the Authority for Nuclear Safety (ASN-Autorité de Sûreté Nucléaire). It is an independent administrative agency headed by 5 members designated by the President of the Republic and the Presidents of the two Parliament Assemblies. The agency is consulted before decisions concerning nuclear safety, nuclear security, and radioprotection are taken by decrees. It can also complete the legislation on technical matters but its decisions may be homologated by the Ministers in charge of these questions. The ASN also has the responsibility of:

- Organizing and directing the control of nuclear installations (designation of inspectors, delivery of permits etc.).
- Monitoring radioprotection over the national territory.
- Proposing and organizing public information on nuclear safety.
- Establishing the procedures for licensing large nuclear installations (licenses for setting up, commissioning, disposal, etc.).
- Helping the management of emergency situation in the event of an accident involving radioactive exposures.

## 3.2. Main National Laws and Regulations in Nuclear Power

### 3.2.1. Organization and structure

***Ministry of Ecology, Energy, Sustainable development and sea (MEEDDM)***

- Direction Générale de l'Energie et du Climat (DGEC)
- DGPR/MSNR

  - Decree n° 2008-680 of 9 July 2008
  - Ordinance of 9 July 2008
  - Atomic Energy commission – Commissariat à l'énergie atomique (CEA)
  - Code of Research, Legislative Part, Book III, Title III, Chapter II : Commissariat à l'énergie atomique -Articles L. 332-1 to L. 332-7 (Atomic Energy Commission).
  - Ordinance n° 45-2563 of 18 October 1945 creating an atomic energy commission.
  - Decree n° 70-878 of 29 September 1970 related to the Commissariat à l'énergie atomique (Atomic Energy Commission).
  - Decree n° 72-1158 of 14 December 1972, as amended, implementing decree 70-878 related to the Commissariat à l'énergie atomique.
  - Law of 9 March 2010 (2010-237): new name for the CEA, as Commissariat à l'énergie atomique et aux energies alternatives

***Nuclear safety authority***

- Law n° 2006-686 of 13 June 2006 on nuclear transparency and safety.
- Decree n° 2002-255 of 22 February 2002 creating the Directorate General for Nuclear Safety and Radiation Protection (DGSNR).
- Decree n° 73-278 of 13 March 1973, as amended, providing for the creation of the High Council for Nuclear Safety and the Directorate General for Nuclear Safety and radiation protection.

***Institute for Radiation Protection and Nuclear Safety (IRSN)***

- Law n° 2001-398 of 9 May 2001 establishing the French environmental safety agency (article 5 creating the Institute for radiation protection and nuclear safety).
- Decree n° 2002-254 of 22 February 2002 related to the Institute for Radiation Protection and Nuclear Safety.

***National Agency for radioactive waste management (ANDRA)***

- Environmental Code, Legislative Part, Book V, Title IV, Chapter II, art. L. 542-12.
- Decree n° 92-1391 of 30 December 1992 creating a national Agency for radioactive waste management.

***Organization in the field of defence***

- Decree n° 2001-592 of 5 July 2001 concerning safety and radiation protection in installations and nuclear activities used for defence purposes.
- Decree n° 78-78 of 25 January 1978 determining the competence or the General Secretary for National Defence (SGDN).
- Decree n° 2000-809 of 25 August 2000 determining the competence and the organization of the General Delegation for Armament (DGA).
- Decree n° 2001-417 of 11 May 2001 concerning the special commission for Basic nuclear installations classified as secret.
- Decree n° 2003-865 of 8 September 2003 providing for the creation of the interdepartmental committee for nuclear or radiological crises.

### 3.2.2. Regulatory provisions for nuclear installations

***Basic nuclear installations (installations nucléaires de base – INB)***

- Law n° 2006-686 of 13 June 2006 on nuclear transparency and safety.
- Decree n° 63-1228 of 11 December 1963 relating to nuclear installations.
- Ministerial Order of 27 April 1982 setting the characteristics of particle accelerators in so far as basic nuclear installations.
- Ministerial Order and Circular of 10 August 1984 concerning Basic Nuclear Installations design, construction and operation.
- Decree n° 85-449 of 23 April 1985 implementing to Basic Nuclear Installations Law n° 83-630 of 12 July 1983 concerning democratization of public inquiries and environmental protection.
- Ministerial Order of 11 March 1996 setting the limits above which factories for the manufacture or processing of radioactive substances and installations for the storage, the disposal or the use of radioactive substances, including waste, are considered as basic nuclear installations.
- Ministerial Order and Circular of November 1999 relating to the monitoring of the

operation of the main primary circuit and of the main secondary circuits of pressurized water nuclear reactors.

- Ministerial Order of 31 December 1999 setting the general technical regulations for the prevention and limitation of detrimental effects and external hazards resulting from the operation of Basic Nuclear Installations.

- Ministerial Order of 12 December 2005 relating to pressurized nuclear equipments.

***Liquid and gaseous effluent release and water intake***

- Decree n° 95-540 of 4 May 1995 relating to liquid and gaseous effluent release and water intake in basic nuclear installations.

- Ministerial Circular of 6 November 1995 relating to Decree n° 95-540 of 4 May 1995 relating to liquid and gaseous effluent release and water intake in basic nuclear installations.

- Ministerial Order of 2 February 1998 concerning water intake and consumption and emissions of installations classified on environmental protection grounds subject to authorisation.

- Instruction of 20 May 1998 concerning licensing in the framework of decree n° 95-540 of 4 May 1995 relating to liquid and gaseous effluent release and water intake in basic nuclear installations.

- Ministerial Order of 26 November 1999 setting the general technical regulations concerning limits and conditions of effluent release and water intake in basic nuclear installations.

- Ministerial Circular of 17 January 2002 – Commentaries on the application of Ministerial Order of 26 November 1999 setting the general technical regulations concerning limits and conditions of effluent release and water intake in basic nuclear installations.

***Installations classified on environmental grounds (installations classées pour la protection de l'environnement – ICPE)***

- Environmental Code, Part. L., Book V, Title I, Chapter I, art. L. 511-1 to L. 517-2, concerning installations classified on environmental protection grounds.

- Decree n° 53-578 of 1st 20 May 1953 related to the nomenclature of installations classified on environmental protection grounds.

- Decree n° 77-1133 of 21 September 1977 implementing Law n° 76-663 of 19 July 1976 concerning installations classified on environmental protection grounds.

***Nuclear installations classified as secret***

- Defence code, Book III, Title II, Chapter II, art. L. 1333-1 to L. 1332-7.

- Decree n° 80-813 of 15 October 1980 amended related to installations classified on environmental protection grounds under the authority of the Defence Minister or subject to national defence secrecy protection rules.

- Decree n° 2001-592 of 5 July 2001 concerning safety and radiation protection in installations and nuclear activities used for defence purposes.

- Ministerial Order of 27 November 2003 relating to the organisation of the Ministry of defence for the operation of military nuclear systems and basic nuclear installations classified as secret, in the field of nuclear security.

- Ministerial Order of 31 January 2006 setting the general technical regulations for the prevention and the limitation of detrimental effects and external hazards resulting from the operation of basic nuclear installations classified as secret.

***Electricity public utility***

- Law 2000-108 of 10 February 2000 concerning modernization and development of the public electricity service, modified by Law 2003-8 of 3 January 2003 concerning gas and electricity markets and electricity public utility, and Law 2004-803 of 9 August 2004 concerning electricity and gas public utilities and electric and gas firms.

### 3.2.3. Radiation Protection

***Protection of public and environment***

- Public Health Code, Legislative Part, Book III, Title III, Chapter III : Ionizing radiation, art. L. 1333-1 to L. 1333-20 and Chapter VI : Penalties, art. L. 1336-5 to L. 1336-9.

- Public Health Code, Regulatory Part, Book III, Title III, Chapter III : Ionizing radiation, art. R. 1333-1 to R. 1333-93.

- Ministerial Order of 27 June 2005 related to the national network for collection of environment radioactivity measurements.

***Protection of workers***

- Labor Code, Legislative Part, Book I, Title II, Chapter II, art. L. 122-3-17 and L. 124-22 and Title III, Chapter I, art. L. 231-7-1

- Labor Code, Regulatory Part, Book II, Title III, Chapter I, art. R. 231-73 to R. 231-116 and Chapter IV, art. R. 234-20, R. 234-22 and R. 234-23

- Decree n° 75-306 of 28 April 1975 relating to protection of workers in basic nuclear

installations.

- Decree n° 86-1103 of 2 October 1986 relating to protection of workers against ionizing radiations hazards.

***Radiological emergency***

- Ministerial Order of 20 December 2002 establishing the national reference guide on radiological hazards.

- Ministerial Order of 13 October 2003 relating to intervention levels in radiological emergency situations.

- Inter-ministerial Instruction of 7 April 2005 on the actions of the administration in case of an event leading to a radiological emergency situation.

- Ministerial Order of 4 November 2005 relating to information of populations in case of radiological emergency situations.

### 3.2.4. Regulatory regime for radioactive materials

- Code of Defence, Book II, Title III, Chapter III : nuclear materials and installations, art. L.1333-1 to L. 1333-14.

- Inter-ministerial Instruction of 28 March 1977 instituting the assistance regime for uranium prospecting.

- Law n° 80-572 of 25 July 1980 concerning protection and control of nuclear materials, as modified by law n° 89-434 of 30 June 1989.

- Decree n° 81-512 of 12 May 1981 concerning protection and control of nuclear materials.

- Decree n° 81-558 of 15 May 1981 concerning protection and control of nuclear materials in the field of Defence.

- Ministerial Order of 14 March 1984 concerning monitoring, confining, supervision and physical protection measures applicable to nuclear materials subject to declaration.

- Ministerial Order of 11 March 1996, repealing Ministerial Order of 24 November 1977 setting the characteristics of radioactive materials under special forms.

- Ministerial Order of 24 September 1996 setting the conditions for the assignment of nuclear materials to military use.

- Ministerial Order of 26 January 2004 concerning protection of national defence secrecy in the field of protection and control of nuclear materials, implementing decree n° 98-608 of 17 July 1998 concerning protection of national Defence secrecy.

- Circular of 26 January 2004 implementing Ministerial Order of 26 January 2004 concerning protection of national defence secret in the field of protection and control of nuclear materials.

- Ministerial Order of 16 March 2004 setting the technical conditions for the monitoring and the accountancy of nuclear materials.

### 3.2.5. Radioactive waste management

- Environmental Code, Book V, Title IV, Chapter II : Radioactive waste, art. L. 542-1 to L. 542-14.

- Law n° 2006-739 of 28 June 2006 relating to radioactive materials and waste

- Decree n° 94-853 of 22 September 1994 on the import, export and transit of radioactive waste between Community member states, as amended by decree 2002-460.

- Decree of 3 August 1999 approving the implementation and operation of an underground laboratory.

- Decree n° 99-686 of 3 August 1999 implementing article 14 of the Law of 30 December 1991 concerning research activities on the management of radioactive waste.

- Decree n° 99-687 of 3 August 1999 implementing article 6 of the Law of 30 December 1991 concerning research activities on the management of radioactive waste.

- Law n° 2000-174 of 4 March 2000 authorizing the approval of the Joint Convention on the safety of spent fuel management and on the safety of radioactive waste management.

- Law 91-1381 of 30 December 1991 concerning research activities on the management of radioactive waste

### 3.2.6. Civil Liability

- Law n° 68-943 of 30 October 1968 concerning nuclear civil liability.

- Decree n° 69-154 of 6 February 1969 related to the publication of the Convention on Third Party Liability in the Field of Nuclear Energy of 29 July 1960, as amended by the Additional Protocol of 28 January 1964 and by the Protocol of 16 November 1982 (Paris Convention).

- Decree n° 94-308 of 14 April 1994 related to the publication of the Convention of 31st January 1963 Supplementary to the Paris Convention of 29th July 1960, as amended by the additional Protocol of 28th January 1964 and by the Protocol of 16th November 1982 (Brussels Convention).

- Insurance Code, Legislative Part., Book IV, Title III- Chapter I : Extraordinary and nuclear risks, art. L. 431-4 to L. 431-7.

- Insurance Code, Regulatory Part., Book IV, Title III, Chapter I : Exceptional and nuclear risks, art. R. 431-27 to R. 431-29.

- Insurance Code, Regulatory Part, Book III, Title III, Chapter I : Technical provisions of others insurance operations, art. R.331-6.

- Decisions of 27 October 1977 concerning exclusion of small quantities of nuclear substances out of nuclear civil liability Convention, from the AEN Committee of Directors.

- Decree n° 91-355 of 12 April 1991 implementing article 4 of the Law 68-943 of 30 October 1968 defining the characteristics of reduced risks installations.

- 3.2.7 Nuclear Test-Ban

- Law 98-217 of 27 March 1998 authorizing the ratification of the Comprehensive Nuclear Test-Ban Treaty (CTBT).

# 4. CURRENT ISSUES AND DEVELOPMENTS ON NUCLEAR POWER

## 4.1. Energy Policy

Two main events regarding Energy policy happened in 2005-2006: the adoption of the 2005-781 Law on Energy, and the release of the report on investments “PPI” as stipulated in the Law 2000-108 on modernization and development of the public electricity service.

- The Law 2005-781 "energy orientation law" has been adopted by the Parliament the 13 July 2005. It indicates the four main goals of the French energy policy:

  - Contributing to the energy independency and guaranteeing the security of supply

  - Ensuring a competitive price of energy

  - Preserving human health and the environment

  - Guaranteeing the social and territorial cohesion.

To reach these goals, four main ways are followed:

- Controlling energy demand (by tax incentives, certification ...)

- Diversifying the energy portfolio (the law stipulates that the State may have a fourth generation nuclear reactor by 2015 in order to eventually replace French nuclear plants, and that 10% of energy needs may be satisfied with renewables by 2010). The site of Flamanville has been chosen by EDF in March 2006 to welcome the demonstrator EPR, after the National Commission of Public Debate organized a debate on the subject from October 2005 to February 2006 and released a report on April 2006.

- Developing Research and Innovation in energy sector (for this purpose, two new agencies, the National Agency for Research -ANR- and the Industrial Innovation Agency -AII- have been created)

- Ensuring the availability of transportation and storage facilities to answer needs

Also, an important stipulation of the law is that Greenhouse Gas emissions must be divided by four up to 2050.

- The Law 2000-108 on modernization and development of the public electricity service of 10 February 2000 stipulates that a report on medium-term power generation capacity investments planning (PPI, Programmation pluriannuelle des investissements) must be prepared by the energy Ministry. Last report on PPI was officially released by the Government in July 2006 and concerns the period 2005-2015. It identifies the following evolutions:

  - Energy savings may be at the heart of any energy scenario, respecting the Law 2005-781 on energy.

  - The share of renewable energy sources -including hydro- of 21% that is targeted in the Law 2005-781 on energy, may be reached in 2013 but not yet in 2010 and mainly with on-shore wind energy. 5 GWe by 2010 and until 12,5 GWe by 2016 of wind capacity are targeted. Hydro may at least be maintained at its current level and could be developed until producing 7 TWh more at maximum. Biomass may be developed until a level of 6 TWh.

  - A 1600 MW EPR reactor may be constructed and be put in operation by 2012.

  - To answer the evolution of the reglementary framework on thermal capacities over the 2005-2015 period that may lead to the shutdown of more than half the coal-fired plants capacity, 5,2 GWe of thermal plants may be constructed (2,6 GWe in semi base-load and 2,6 GWe in peak-load) by 2015, among which 0,8 GWe by 2009. Also, 2,6 GWe of old oil-fuelled plants may be modernized by EDF to re–enter into operation

Regarding nuclear energy, the report indicates that nuclear production through the existing plants is going to stabilize after having strongly increased last years.

The report must be presented and discussed by the Parliament, and followed by a decree from the government.

## 4.2. Privatization and deregulation

In the wake of successive legislations, the role of public authorities has changed.

The European directives on electricity market liberalization have been implemented in the French legislation through law n° 2000-108 of 10 February 2000 on the modernization and development of the public electricity service. This law states in its first article:

*“The purpose of the public electricity service is to guarantee electricity supplies throughout the country, having due regard to general interest.*

*In the context of the energy policy, the public electricity service contributes to the independence and security of supply, air quality and combating the greenhouse effect, optimum management and development of national resources, control of demand for energy, economic competitiveness and control of technical choices for the future, as well as efficiency in energy use.*

*It furthers social cohesion, by ensuring the universal right to electricity, contributes to combating exclusion, a balanced spatial development, having due regard to the environment, research and technological progress as well as defence and public order.*

*The public electricity service shall be organized by the State and the local authorities or their public co-operation establishments, each for its part."*

It follows from this article that the government retains the responsibility of establishing objectives regarding security of energy supply or regional planning. In addition it remains responsible for defining and enforcing adherence to the rules within which the various market players must act. Of course, public authorities retain the traditional governmental activities such as preparation and development of regulations, energy taxation, public service obligations, personnel and installation safety, environment protection, in particular implementation of the European directives regarding greenhouse gases emissions and the share of renewable energies in electricity production. They also keep the general responsibility of insuring long term supply by supporting R&D efforts when private companies would not engage by themselves appropriate involvement. In addition, through the procedure of call for bids or the authorization required for the new production plants (decree n° 2000-877 of 7 September 2000), the government keeps the ability to set conditions for new power units, including the energetical, technical, economic, financial and geographical characteristics of the installation. (for instance regarding greenhouse gas emissions or other pollutants, long term supply stability or use of domestic energy resources), and thus influence the choice of the energy sources.

Regarding public service obligations, the law of 10 February 2000 has created a specific contribution (*Contribution au service public de la production d'électricité, CSPE)* intended for compensating the excess costs attributable to public service obligations (purchase obligation for green electricity, power production in non-connected zones such as overseas *départements*, etc.). This fund is supplied by the different electricity producers established in the French territory including auto-producers as well as by the electricity importers.

Regarding the European directive on renewable energy, France is due to raise the share of renewable electricity from the actual value of about 15% to 21%. To this aim, the hydro power availability being already used almost at full, special effort is made to increase the contribution of wind energy.

Since the 1st of July 2007, any company and household are actually free to choose their energy supplier on the French electricity market.

The public companies EDF and GDF, created in 1946, became limited liability companies the 19th of November 2004, according to the Act of August 9, 2004. This new legal form means that both companies were no longer bound by the "specialty principle" that was attached to their status of state-owned company (EPIC) since 1946. GDF increased its capital by 30% in June 2005 and merged with Suez in July 2008. EDF increased its capital by 30% in October 2005 (the law stipulates that the French State holds at least

70% of the capital and voting rights in EDF SA and GDF SA).

The other public companies are now widely open to the private sector: the coal fired plants operator SNET (*Société Nationale d'Electricité et de Thermique*) is now owned by E.ON, the company *Energie du Rhône*, that trades the electricity production of the hydropower stations of CNR *(Compagnie Nationale du Rhône*) is partly owned by Electrabel (GDF-Suez).

## 4.3. Safety and Waste Management issues

Nowadays, 84% of radioactive wastes volumes produced by French operators are subject to a long term management. The other ones are conditioned and stored before a final solution. Thus, the ANDRA (Agence Nationale pour la gestion des Déchets Radioactifs) manages existing storage facilities.

- Very low level wastes: the disposal center in Morvilliers (Aube) designed to receive 650 000 tonnes of wastes over 2030's and which was inaugurated during the summer 2003 is now fully operating.

- Low and intermediate level wastes: the disposal center of la Manche does not receive materials since 1994. It is now under a watching process since 2003. The disposal center of Aube has welcome 12 700 m3 more in 2007.

- High-level and long-lived radioactive wastes: the law n° 91-1381 on Research and Management of nuclear wastes of 30 December 1991 defined three complementary lines of research aimed at finding a solution for managing high-level and long-lived intermediate-level radioactive waste over the very long term:

  - Partitioning and transmutation of long-lived radioactive elements (axe 1)

  - Reversible and irreversible deep geological disposal (axe 2)

  - Conditioning and long-term near-surface storage (axe 3).

It entrusted the CEA with the first and third axes and ANDRA with the second. In 1999, the government approved the decision to create a laboratory on a clay site in Bure. The experimental area at – 490 m is operational since April 2005.

This law 91-1381 also specified that after 15 years of research (so, in 2006), the government might submit a draft law on nuclear wastes to the Parliament. The government organised a public debate that happened from September 2005 to January 2006 and then transmitted a draft law in March 2006. The Parliament modified and adopted the Law 2006-739 on "sustainable management of nuclear wastes and materials" the 28 June 2006.

The Law 2006-739 creates a National Plan of nuclear wastes management, and institutes a program to implement it. It shapes 3 main lines:

- In order to reduce the quantity of wastes, used nuclear fuels are treated to be recycled in Nuclear Power Plants.

- Wastes that cannot be recycled are conditioned in casks and temporarily stored on

surface.

- After storage, wastes that cannot finally be stored on surface are disposed under a deep geological disposal facility.

A National Commission must evaluate annually the progress of research. The building of a storage facility will be submitted to a Prime Minister decree by 2015 after examination of the project by the ASN and a public debate.

Furthermore, the Law 2006-739 specifies a framework on the financing and dismantling of nuclear facilities and wastes management in order to secure their provisioning. Utilities must constitute dedicated assets, and secure their availability.

A High Committee for Transparency and Information on Nuclear Security is created by the Law 2006-686 on transparency and safety of 13 June 2006. It must regularly organise debates on sustainable management of nuclear wastes.

## Appendix 1: International, Multilateral and Bilateral Agreements

*AGREEMENTS WITH THE IAEA*

| | | |
|---|---|---|
| • Agreement on privileges and immunities | Non-Party | |
| • Voluntary offer: Agreement with the European Atomic Energy Community for the application of safeguards in France; INFCIRC No: 290 | Entry into force: | 12 September 1981 |
| • Additional protocol to the Agreement with the European Atomic Energy Community for the application of safeguards in France | Entry into force: | 30 April 2004 |
| • Safeguards Agreement under the additional protocol I to the Tlatelolco Treaty; GOV/1998/31 | Entry into force: | 21 October 2007 |
| • Tlatlelolco Treaty | | |
| • Additional protocol n°1 | Entry into force: | 24 August 1992 |
| • Additional protocol n°2 | Entry into force: | 22 March 1974 |
| • EURATOM | Member | |

*OTHER MULTILATERAL SAFEGUARDS AGREEMENTS WITH IAEA*

| | | |
|---|---|---|
| • Japan / France INFCIRC/171 | Entry into force: | 22 September 1972 |
| | Modified | 1990 |
| • Republic of Korea / France INFCIRC/233 | Entry into force: | 22 September 1975 |
| • Pakistan / France INFCIRC/239 | Entry into force: | 18 March 1976 |
| • Exchange of letters between the governments of France and the Republic of Iraq supplementary to the Franco Iraqi co-operation agreement for the peaceful utilization of nuclear energy INFCIRC/172/add.1 | Entry into force: | 4 November 1976 |
| • South Africa / France | | |

| | | |
|---|---|---|
| INFCIRC/244 | Entry into force: | 5 January 1977 |

*MAIN INTERNATIONAL TREATIES*

| | | |
|---|---|---|
| • NPT | Entry into force: | 3 August 1992 |
| • Convention on physical protection of nuclear material INFCIRC/274 | Entry into force: | 6 October 1991 |
| • Convention on early notification of a nuclear accident INFCIRC/335 | Entry into force: | 6 April 1989 |
| • Convention on assistance in the case of a nuclear accident or radiological emergency; INFCIRC/336 | Entry into force: | 6 April 1989 |
| • Vienna conventions on civil liability for nuclear damage | Non Party | |
| • Paris conventions on third party liability in the field of nuclear energy | Entry into force of | 9 March 1966 |
| • Joint protocol relating to the application of the Vienna and Paris conventions | Signature: | 21 June 1989 |
| • Protocol to amend the Vienna convention on civil liability for nuclear damage | | Not signed |
| • Convention on supplementary compensation for nuclear damage | Not signed | |
| • Convention on nuclear safety | Entry into force: | 24 October 1996 |
| • Joint convention on the safety of spent fuel management and on the safety of radioactive waste management INFCIRC/546 | Entry into force: | 18 June 2001 |

*OTHER UNDERTAKINGS*

| | | |
|---|---|---|
| • Antarctic treaty | Entry into force: | 16 September 1960 |
| • London Convention | Entry into force: | 5 March 1977 |
| • OSPAR Convention | Entry into force: | 25 March 1998 |
| • Rarotonga Treaty | Signature: | 25 March 1996 |

| | | |
|---|---|---|
| • Comprehensive Test Ban Treaty | Ratification: | 6 April 1998 |
| • Zangger Committee | Member | |
| • Improved procedures for designation of safeguards inspector | Accepted on: | 26 April 1989 |
| • Nuclear Suppliers Group | Member | |
| • Acceptance of NUSS Codes | Summary**:** Generally positive; will be taken into account for own regulations; compatible with national regulations. (Letter of 9 August 1988) | |
| • Nuclear Export Guidelines | Adopted | |

*BILATERAL AGREEMENTS*

| | | |
|---|---|---|
| • France / Russian Federation | Signature: | 19 April 1996 |
| • France / Ukraine | Signature: | 3 September 1998 |
| • France / Japan | Signature | 26 February 1972 |
| • France / Mexico | Signature | 02 February 1979 |
| • France / Egypt | Signature | 27 March 1981 |
| • France / Republic of Korea | Signature | 4 April 1981 |
| • France / Switzerland | Signature | 5 December 1988 |
| • France / Argentina | Signature | 21 April 1994 |
| • France / China | Signature | 15 May 1997 |
| • France / Brazil | Signature | 25 October 2002 |
| • France / United Arab Emirates | Signature | 31 January 2008 |
| • France /Algeria | Signature | 21 June 2008 |
| • France/Jordan | Signature | 30 May 2008 |
| • France / Russian Federation | Signature: | 20 June 2000 |
| • (on civil nuclear liability) | | |

# Appendix 2: DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

Direction Générale de l'Energie et du Climat (DGEC), MEEDDM
Grande Arche de la Défense Paroi Nord — http://www.developpement-durable.gouv.fr/
F-92055 la Défense Cedex — Tel: + 33 (0)1 40 90 20 00

*ATOMIC ENERGY COMMISSION*

Commissariat à l'énergie atomique et
aux énergies alternatives(CEA)
Saclay — Tel.:+33 (0)1 69 08 60 00.
91191 Gif sur Yvette — http://www.cea.fr/

Institut National des Sciences et Techniques
Nucléaires (INSTN, National Institute for
Nuclear Science and Technology;
also under the Ministry of Education) — http://www.instn.fr/

*OTHER NUCLEAR ORGANIZATIONS*

ASN
6 place du colonel Bourguoin — Tel.:+33 (0)1 40 19 86 00
F-75012 Paris — http://www.asn.gouv.fr

Institut de Radioprotection et de Sûreté Nucléaire — Tel:+33 (0)1 58 35 88 88
(IRSN, Nuclear Safety and Radioprotection Institute) — Fax:33 (0)1 58 35 84 51
BP17
F-92262 Fontenay-aux-Roses Cedex — http://www.irsn.fr/

Or
77-83, avenue du Général-De-Gaulle
F-92140 Clamart

Comité Interministériel de la Sécurité Nucléaire
13, rue de Bourgogne
F-75007 Paris — Tel.:+33 (0)1 43 19 56 78

Agence Nationale pour la Gestion
des Déchets Radioactifs (ANDRA)
Parc de la Croix Blanche — Tel.:+33 (0)1 46 11 80 00
1-7, rue Jean Monnet — Fax:+33 (0)1 46 11 82 68
F-92298 Chatenay-Malabry Cedex — http://www.andra.fr/

*OTHER ORGANIZATIONS IN THE NUCLEAR INDUSTRY*

| | |
|---|---|
| Electricité de France (EDF)<br>22 -30, avenue de Wagram<br>F-75382 Paris Cedex 08 | Tel.:+33 (0)1 40 42 22 22<br>Fax:+33 (0)1 40 42 13 32<br>http://www.edf.fr/ |
| AREVA SA<br>33 rue Lafayette<br>F-75 442 – Paris Cedex 09 | Tel:33 (0)1 34 96 00 00<br>Fax:+33 (0)1 34 96 00 01<br>http://www.arevagroup.com |
| AREVA NC<br>33 rue Lafayette<br><br>F-75442 Paris Cedex 09 | Tel.:+33 (0)1 34 96 00 00<br>Fax:+33 (0)1 34 96 00 01<br>http://www.areva-nc.com |
| AREVA NP<br>Tour AREVA<br>1 place Jean Milier<br>F-92084 Paris-La Défense Cedex | Tel.: +33 (0)1 34 96 60 10<br><br>http://www.areva-np.com |

*HIGH ENERGY INSTITUTES*

| | |
|---|---|
| Centre National de la Recherche Scientifique (CNRS) | http://www.cnrs.fr/ |
| European Synchrotron Radiation Facility – Grenoble (ESRF) | http://www.esrf.fr/ |
| Institut National de Physique Nucléaire et de Physique des Particules (IN2P3) | http://www.in2p3.fr:80/ |
| Laboratoire pour l'Utilisation du Rayonnement Electromagnétique - CNRS (LURE) | http://www.lure.u-psud.fr/ |
| Synchrotron SOLEIL | http://www.synchrotron-soleil.fr/ |
| DRFC-CEA Cadarache<br>(Département de Recherches sur la Fusion Contrôlée) | http://www.cad.cea.fr/r50.htm |

*INTERNATIONAL ORGANIZATIONS*

| | |
|---|---|
| European Science Foundation | http://www.esf.org/ |
| European Space Agency (ESA) | http://www.esa.int/ |
| IEA International Energy Agency | http://www.iea.org/ |
| Nuclear Energy Agency of the OECD (NEA) | http://www.nea.fr/ |
| Organization for Economic Co-operation and Development (OECD) | http://www.oecd.org/ |

*OTHER ORGANIZATIONS*

| | |
|---|---|
| Société Française de l'Energie Nucléaire (SFEN) | http://www.sfen.org/ |
| World Council of Nuclear Workers (WONUC) | http://www.wonuc.org/ |