# ALICE Electricity Sector Country Study: France

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## Contents

# 1 Introduction

The electricity sector in France is unique in Europe for both its high share of nuclear power plants[1] as well as its reluctance to liberalization enforced by the European Union since the late 1990s. Both aspects appear to be rooted in the historical evolution of the French electricity sector after the second world war. This study aims at describing the current situation and making it plausible as as a result of this historical evolution.

The outline follows the structure suggested in Michael's "Country Comparison Catalog" (CCC), after a brief historical wrap-up of the evolution of France's electricity system. This is interesting, in particular because the major decisions that have led to the current situation in France have been made shortly after World War II and in the mid-1970s, while the past 20 years (which are represented by most data sets) have been relatively quiet.

# 2 A Brief History of the French Electricity Sector

After the introduction of the first distribution networks in 1884, the electricity system of France had evolved with virtually no centralized planning. As a result, around 1940 about 1,500 companies were engaged in generation, transport and distribution of electricity, which were supported by some 20,000 concession holders (Answers.com, 2007b). The system turned out to be highly inefficient and sometimes even irrational, as utilities sometimes competed directly in the same place. Therefore, in 1946 the French government decided to establish a single nationalized utility for electricity (and another for gas) as part of its strategy to modernize the French economy (Answers.com, 2007b). Although the newly created *Électricité de France* (EdF) ostensibly was under public control, it was (and probably still is) run by an technical elite of graduates of the *grandes écoles*, with a high degree of independence (Hadjilambrinos, 2000).

Given France's poor endowment with fossil resources, EdF quickly embarked on a program of massive hydroelectric plant construction. By 1960, the dams (mostly in the French Alps) produced over 37.1 TWh of electricity, representing then 71.5 percent of EdF's total production (Answers.com, 2007b). In the 1960s, however, demand continued to increase, while the possibilities for hydro power expansions started to reach their limits, and EdF again had to search for additional energy sources. As urbanization, prosperity and changed individual lifestyles in the postwar period had led to greater variability in electricity demand, oil was the manifest solution: it was cheap and oil-fired plants provided flexible output to meet varying demands. By 1973, oil-fired plants contributed 59.7 TWh or 43 % to EdF's production compared to only 3 percent in 1960 (Answers.com, 2007b).

In parallel, EdF had started to investigate other energy sources, like wind, tidal power and nuclear fission, while only the latter was heavily promoted. It is clear, that both the prospect of a cheap and abundant power source, as well as the linkages to the French nuclear arms program were important factors in this decision. Furthermore, according to Hadjilambrinos (2000), symbolical and psychological factors among the technocratic elite in EdF's headquarters (and in government) played a key role: "[N]uclear technology was viewed as essential for the restoration of France to its former glory and international position." (Hadjilambrinos, 2000: 1115). The nuclear programme was thus developed and maintained in spite of technical problems causing delays, and even thought the expected cost reductions could not be reached during the initial phase in the 1960s, although there were strong resistant forces, namely within the

[1] Globally, only Lithuania has a higher share (IEA 2004).

French Ministry of Finance (Hadjilambrinos, 2000).

These objections were easily swept away after the 1973 oil crisis, when the government decided to prioritize nuclear power as a means to significantly reduce dependence in energy. The so-called 'Messmer plan' (named after prime minister Messmer) foresaw the installation of some 13 GW nuclear power plants within only two years (Answers.com, 2007b; Hadjilambrinos, 2000). The Messmer plan, based on the visions of EdF's technocrats of an "all-electric, all-nuclear society", and enforced as a purely administrative decision without parliamentary debate (Hadjilambrinos, 2000), set the framework for the French energy policy on the past 30 years, leading tho the current energy mix, which is described in in more detail section 3.

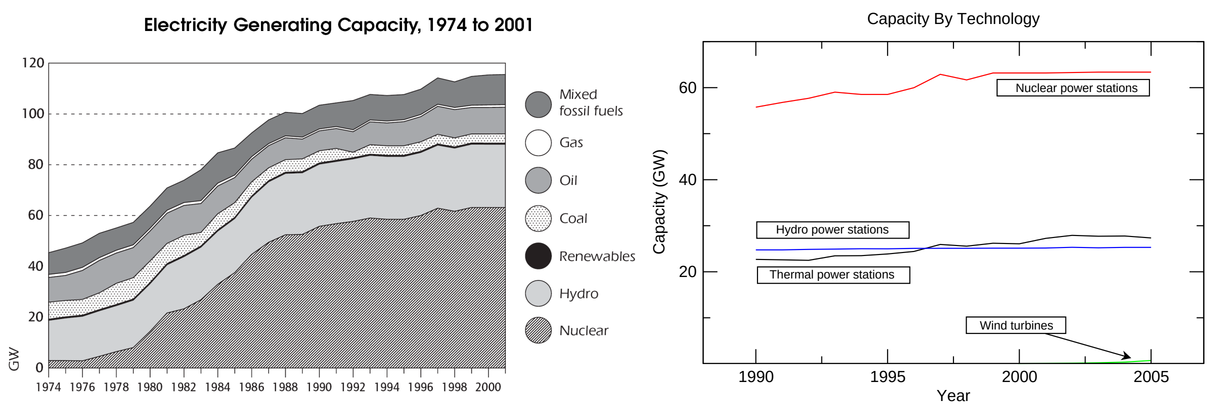
By the mid-1980s it became obvious that overestimated demand projections and the goal of energy independence had led to a huge overcapacity of nuclear power, whose construction required EdF to borrow heavily from international capital markets and leading to an annual loss of 4 bn FFr in 1989 and a long-term debt of 226 bn FFr (Answers.com, 2007b). Around the same time, EdF expanded its electricity exports to most European neighbors, including the UK. It was also quickly present in Eastern Europe after 1990 (East Germany, Bulgaria), and started to purchase company stakes abroad (Sweden, Brazil, Poland). The effects of the liberalization of European energy markets will be described in sections 6 and 8.

# 3 Current Situation: Basic Data

## 3.1 Electric Power Capacity

In 2005, France had an installed capacity of 116.7 GW (NRG 113a) for electricity generation (see Figure 1). About 54 % of this capacity is allocated in nuclear fission reactors, some 23 % in thermal and 22 % in hydro power stations. Since the expansion of nuclear power came to a virtual halt in th early 1990s, these shares have been relatively constant, the slow increase of capacity (+0.7 %/year) has been covered by few additional nuclear and thermal power. The total contribution of renewable energies is 1 %, with 723 MW from wind turbines and some 600 MW from combusted biomass (i.e. wood and waste incineration) (NRG 113a).

**Figure 1:** Net installed electric capacity in France. Left: cumulative capacity. Right: capacity by generation technology. Note that the panels have different abscissas.
Sources: IEA, 2004 (left), NRG 113a (right)



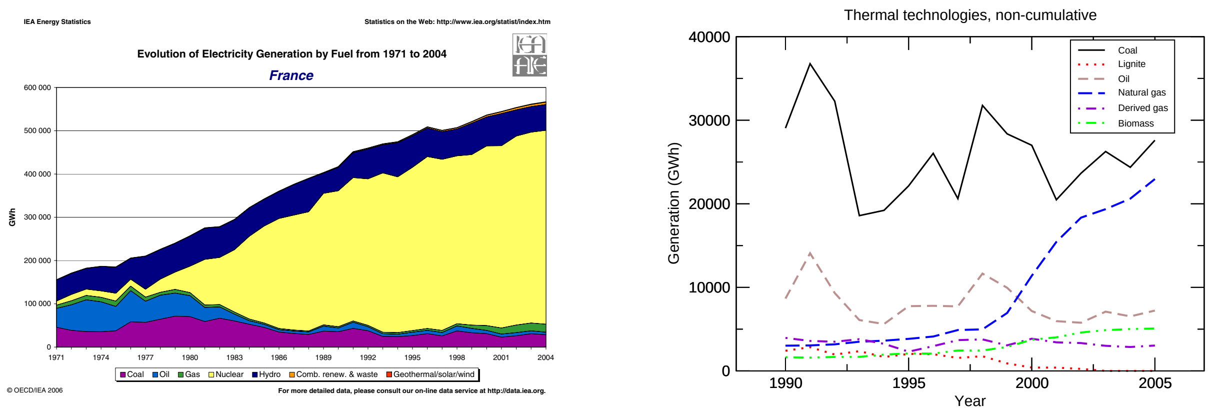
## 3.2 Electricity Production

Despite the small increase of installed capacity, the actual electricity production has increased by 155 TWh/year between 1990 and 2005, reaching 575 TWh/a in 2005 (NRG 105a) (see Figure 2). This corresponds to an average annual increase by 2.2 %. Since 1971, the growth rate has even been 3.6 % (IEA 2004: 120). Electricity production in 2005 is mainly provided by nuclear power (78 %), followed by thermal plants (11 %) and hydro power (10 %). Thermal plants include combusted biomass (waste incineration, wood/wood wastes, and biogas), which amounted to 5 TWh in 2005 (0.8 % of total consumption). Wind turbines provided only 959 GWh (0.1 %) in 2005. Obviously, non-hydro renewable energy sources play only a minor role in the French energy mix. The high share of electricity production from the 'domestic' primary energy carriers hydro and nuclear makes France independent of foreign electricity and allows for huge net exports (see sections 3.3 and 4).

Note that the share of oil used for electricity generation has drastically declined since the late 1970s as a result of the 1973 oil crisis[2]. Coal was initially used to substitute oil but returned to its early 1970s level when nuclear power became the backbone of France's electricity supply in the early 1980s. Since 2000, natural gas also plays an increasingly important role.

**Figure 2:** Gross electricity generation in France. Left: cumulative generation 1971-2004. Right: generation from thermal generation technologies 1990-2005.

Sources: http://www.iea.org/textbase/stats/pdf_graphs/FRELEC.pdf (left); NRG 105a (right)




## 3.3 Electricity Demand and Trade

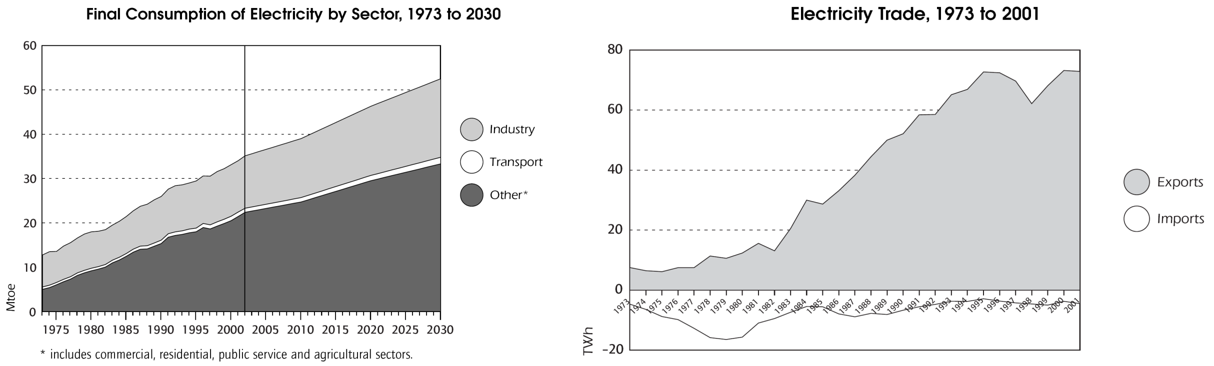
The large nuclear capacity installed during the 1980s resulted in huge overcapacities, which could easily absorb the steady, but much slower than originally expected increase in domestic electricity demand (see Figure 3, left). Demand increase for electricity is mainly driven by non-industrial sectors, namely the services and the residential sectors.

As already mentioned in section 1, the other obvious way to deal with the existing overcapacities was to look for additional customers abroad. Consequently, the export of electricity increases significantly as soon as the first bulk of nuclear plants were operational in the mid-1908s. Since the mid-1990s, France exports more than 60 TWh/yr, or more than 10 % of its

[2] Interestingly, the existing capacity for oil did not decline in the same way, as can be seen in Fig. 1. This implies that the old oil plants are still there, though currently not in use.

annual production, mainly to Italy, Germany, the UK, Belgium, Switzerland and Spain. Recently, imports have started to increase after the opening of the electricity market, see section 8.3 for details.

**Figure 3:** Left: Domestic electricity demand by sector. Right: Electricity trade.
Source: IEA, 2004




## 3.4 Load Factors

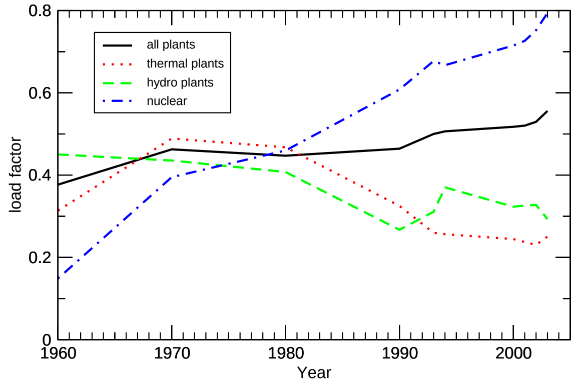
Although peak loads sometimes reach 73 % of total capacity (see Table 1), average load factors (i.e. the amount of power produced divided by the engineering capacity of the plant, averaged over one year) in France are relatively small (see Figure 4 left) when compared to other countries, in particular for the nuclear plants, where industrialized countries typically have load actors of (far) more than 80 % (Maloney, 2003). This is due to the huge overcapacities that have been built up during the 1980s (see section 1). Although capacity utilization steadily increased over the past two decades as a result of growing domestic demand and increased electricity exports (see Figure 3), it is still among the lowest values in Western Europe (Maloney, 2003).

**Table 1:** French record loads on the electricity grid.
Source: RTE, 2007

| Date | Load [GW] | Load/Capacity [%] |
|---|---|---|
| 27.01.2006 | 86.28 | 73.9 |
| 25.01.2007 | 86.26 | 73.9 |
| 28.02.2005 | 86.02 | 73.7 |
| 05.01.2006 | 84.98 | 72.8 |
| 26.01.2005 | 84.71 | 72.5 |

The high share of nuclear power in the French electricity mix and the associated small load factors have the additional sub-optimal side-effect, that French nuclear power plants are often run in load-following mode (UIC, 2007), i.e. their actual power is set according to electricity demand (and plants are sometimes even switched off for the week-end), instead of running them constantly to cover the grid's base load. Under such conditions, the other plant types also will not to be operated as efficiently as they could, which explains the low overall load factors.

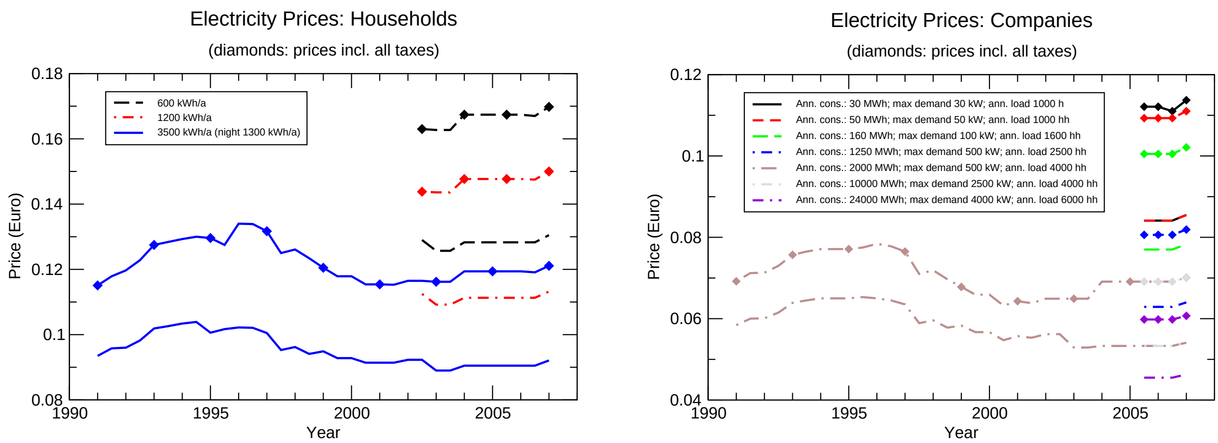
**Figure 4:** Averaged annual load factors in French electricity generation.
Source: own calculation based on IAEA CNPP (1998, 2002, 2003, 2004)




## 3.5 Electricity Prices

As in many European countries, most consumer prices for electricity are regulated. And, as usual for many utilities, electricity prices for households are higher than those for industrial consumers, and within these groups prices per kWh decline with annual consumption (see Figure 5). Additionally, the tax burden per kWh is higher for households than for industries (0.03–0.04 € vs. 0.02–0.03 €), where the upper values of both ranges belong to small customers. This is related to a differential taxation scheme, where fixed price components are subject to a reduced VAT of 5.5 %, while variable components are taxed at the normal rate of 19.6 % (IEA, 2004). Electricity is also subject to several small taxes, often collected at the local rather than the national level. These electricity taxes (excluding VAT) amount to 0.45 eurocents per kWh for industry and 1.42 eurocents per kWh for households (IEA, 2004)

**Figure 5:** Electricity prices for various consumer types. Left: Households. Right: Industrial consumers
Source: NRG 204, NRG 205



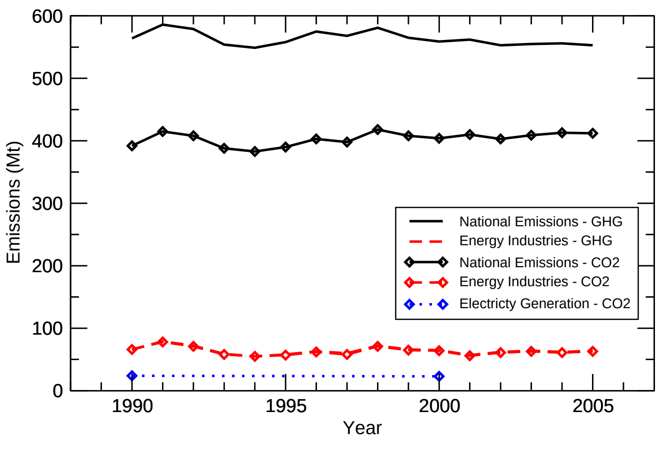

Compared to other IEA countries, French prices tend to be in the lower range for industry prices, while household prices are close to the IEA average (IEA, 2004). Interestingly, IEA (2004) reports higher household price fluctuations in the past than Eurostat (NRG 204), the reason of which could not be resolved; it may be an effect of aggregation and/or currency conversion.

The entry of new suppliers into the French electricity market according to the EU liberalization directive (see section 6) had no significant effect on prices. There is only one small dip in 2003, which may be related to lowering the threshold above which industrial consumers could choose their supplier down to 7 GWh/year, but later reductions of this threshold did not show any effect, and there was a similar dip for households as well, which were not affected by market liberalization in 2003.

### 3.6 Greenhouse Gas Emissions

Greenhouse gas as well as $CO_2$ emissions in France have been virtually stable since 1990 (see Fig. 6). The 400 Mt $CO_2$ constitute some 70 % of the national GHG emissions (some 560 Mt $CO_2$ equivalent). Only 12 % of GHG are emitted by energy industries (16 % of national $CO_2$ emissions). Within the energy sector, electricity generation is responsible for about 1/3 or about 23 Mt of $CO_2$ emissions. All these comparably small figures are, of course, again due to the high share of nuclear power in electricity generation. This also holds for the per capita emissions of total GHG emissions, which dropped from 9.5 t of $CO_2$ equivalent in 1997 to 8.8 t in 2005 due to an increase in population.

**Figure 6:** Greenhouse gas (as $CO_2$ equivalent) and $CO_2$ emissions (diamonds) in France. For the energy sector (dashed lines) both curves are almost indistinguishable, indicating that the energy sector virtually emits no other GHG than $CO_2$.
Source: ENV_AIR_EMIS; Eurelectric, 2002




## 4 Resource Endowment

### 4.1 Available Fossil Resources/Reserves

Conventional (i.e. fossil and nuclear) resources are few in France (see Table 2). Typically, inland production exceeds domestic production by at least one order of magnitude, so that France is dependent on imports. With respect to electricity production this is particularly valid for uranium, where domestic production was shut down in 2002 when the reserves were exhausted (BGR 2003). There are, however, still considerable reserves and resources of oil, gas and coal, although prospects are different: while investments to explore new extraction sites for oil and gas grew by 27 % in 2006 and exploration is actively supported by the government, the last coal mines have been shut down in 2004 (DGMEP 2007), as domestic coal is no longer competitive to imports.

**Table 2:** French non-renewable resources and reserves. Data are from 2001/2 or 2004/5, depending on the source.
Source: BGR 2003, 2006

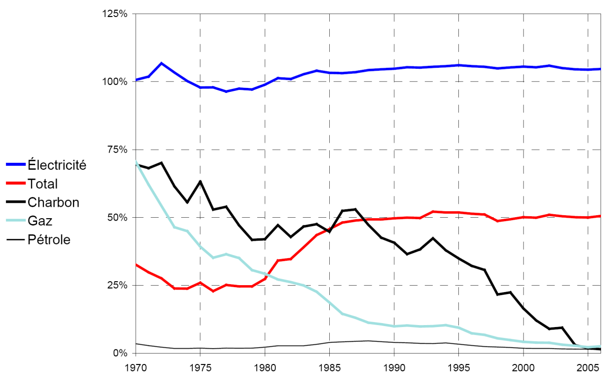
| Fuel type | Reserves | Resources | Production | Consumption |
|---|---|---|---|---|
| conventional oil (Mt) | 22 | 70 | 1.1 | 94.7 |
| conv. natural gas ($10^9$ $m^3$) | 11 | 300 | 1.1 | 45 |
| hard coal (Mt) | 116 | 274 | 4.4 | 19.6 |
| lignite (Mt) | 5 | 110 | 0.3 | n.a. |
| Uranium (t) | 300 | n.a. | 120[a] | 10146[b] |

[a]Production of uranium stopped in 2002.
[b]ABS, 2007, which is consistent with the 102.4 Mtoe from BGR, 2006

## 4.2 Use of Domestic Fuels in Electricity Production

Despite the high amount of imported fossil fuels in the total primary energy mix, the overall energetic independence of France has remained relatively stable around 50 % since the late 1980s (see Figure 7). The reason is, again, the high amount of nuclear and hydro electricity, which

**Figure 7:** Energetic independence for various primary energy forms. Primary electricity consists of nuclear and hydro only.
Source: DGEMP, 2007a




are accounted for as domestic primary energy[3], and whose growth has balanced the strongly

[3]The author is still puzzled by the fact that nuclear power is counted as domestic primary energy albeit the required uranium has to be imported.

decreasing independence rates for fossil fuels. Note, that the autarky in primary electricity arises from this definition and has nothing to do with the actual electricity mix – even if France had only one hydro plant and would produce all other electricity from imported oil, primary electricity independence would remain at 100 % as long as there are no imports of hydro power.

Note that renewable energies have not been included in Figure 7. Their energetic independence levels are virtually 100 % (DGEMP, 2002, 2004, 2007a), indicating that France currently does neither export nor import significant amounts of primary renewable energy sources (e.g. biomass, wind power, solar electricity).

### 4.3 Potentials for Renewable Energy Sources

The potentials for renewable energy sources (RES) differ widely between sources and the publication date. As a general rule, more recent studies give greater estimates, because technological progress allows greater energy yields under given conditions (particularly for wind and solar power), or expands the range of conditions where a given technology can be applied. A nice example are estimates of the French wind energy potential: in 1995, it was estimated to 24.3 TWh/year (Espey, 2001). By 2004, the estimates had increased to 85 TWh/year for onshore sites and an additional offshore potential in the range of 44–477 TWh/year (WEA, 2004). Thus, there is some probability that the figures stated in Table 3 will increase in future estimates.

**Table 3:** French potential and use of renewable energy sources (RES) for electricity generation.

| RES | Tech. Potential [TWh/year] | Actual usage [TWh/year] | used Pot. [%] | Source(s) |
|---|---|---|---|---|
| Wind onshore | 85 | 1.0 | 1.2 | EWEA, 2004; NRG 105a |
| Wind offshore | 44–477 | 0[a] | 0 | EWEA, 2004 |
| Hydro small | 7.9 | 5.8 | 73.4 | Espey, 2001; NRG 105a |
| Hydro large | 64.0 | 45.9 | 71.8 | Espey, 2001; NRG 105a |
| Solar, el. | 30.9–134[b] | 0.035 | 0.1 | Espey, 2001; ObservER, 2007 |
| Biomass | 64.4[c] | 5.1 | 7.9 | Espey, 2001; NRG 105a |
| Tidal | 37.0 | 0.53 | 1.4 | Espey, 2001; ObservER, 2007 |
| Geotherm., el. | 1.0 | 0.095 | 9.5 | Espey, 2001; ObservER, 2007 |

[a] First offshore plant shall start operation in 2008 (105 MW, expected 310 GWh/year) (Enertrag, 2007).

[b] Upper value: own estimate based on (Šúri et al., 2007) and the assumption, that about 10 % of the residential areas ($1.16 \cdot 10^{10}\,m^2$, INSEE, 2007) can be used for PV modules.

[c] Own estimate, assuming that the unspecified 195 TWh/year from (Espey, 2001) can be used for electricity generation with an efficiency of 33 %.

Apparently, current RES utilization taps the available potential only for hydro power. Interestingly enough, EdF states on their website that “more than 90 % of France’s hydro power potential has already been harnessed” (EdF, 2007a). As annual production levels have been above 70 TWh for many years in the 1990s, this statement remains somewhat mysterious. Apart from that it becomes clear from Table 3, that there are few technological limits to increase the share of RES in French electricity generation.

# 5 Investments and Decommissions of Plants and Installations

After the build-up of the nuclear power plant park according to the Messmer plan had come to an end in the early 1990s, the expansion of the French electric capacity virtually stopped (see sections 1 and 3.1). This was due to the acquired overcapacities and the slower-than-predicted growth in demand. Recent projections, however, predict further demand increase for the next centuries, which have to be met in a liberalized market, where companies are free to build and decommission plants, provided local siting permits are obtained.

Nevertheless, investments in the French electricity sector are still influenced by the government in three ways (IEA, 204): First, a feed-in tariff and the obligation for the distribution network operators to buy RES and cogeneration electricity described in section 6.1). Second, the support of building the European Pressurized Water Reactor (EPR). Third, through a commission, which prepares the multi-annual programme on investments in electricity production (PPI, programmation pluriannuelle des investissements de production d'électricité). Its primary goal is "to identify desirable investments in electricity production with respect to security in electricity provision" (DGEMP, 2007c, own translation). The PPI defines objectives for new investments as well as for the primary energy mix and conversion techniques to be employed and takes regional disparities into account. It also takes into account the EU obligation to produce 21 % of French electricity from RES by 2010. If the requirements of the PPI are not met by market forces alone, the ministry of energy may submit a call for offers in order to build the required capacities (DGEMP, 2007c). This procedure has been used five times, mostly to initiate the construction of wind and biomass driven plants (CRE, 2007c).

The current PPI (of June 13, 2006) has a time horizon until 2015. Major goals are:

- develop RES:
  - boost wind energy up to at least 5 GW in 2010 and 12.5 GW in 2016[4],
  - at least additional 6 TWh of biomass by 2016[5]
  - maintain hydroelectric production
- have the EPR (European Pressurized water Reactor) operational in 2012 (EdF has long decided to build this 1500 MW reactor at Flamanville. The final construction phase 2007–2012 requires investments of 3.3 bn €.)
- reactivation of 2.6 GW oil-fired plants (already announced by EdF, investment sum not specified)
- new installation of 500 MW combustion turbines (already announced by EdF). The PPI identifies another 0.8 GW that need to be operational until 2009, and 5.2 GW until 2015.

EdF has announced the construction of gas turbines with almost 2 GW capacity with an investment volume of 900 mio €. They also announced to invest 500 mio € for the maintenance of existing hydro facilities within the "superhydro" programme (EdF, 2007b).

Legal limitations exist for fossil fueled thermal plants: they have been limited to 20,000 hours of full operation between 2008 and 2015, of which oil-fired plants may be used only 5 % of the time on average, i.e. less than 500 hours per year (DGEMP, 2006b). (This limitation

[4] Specific investment costs for wind power are ca. 1000€/kW.

[5] Specific investment costs for biomass: 2000-3000€/$kW_{el}$ (IE, 2003).

clearly results from attempts to reduce energy imports, which in this case goes in line with $CO_2$ reduction.) According to the PPI, about half of the coal-fired plants (i.e. a capacity of 3.8 GW) shall be decommissioned by 2015 (DGEMP, 2006b). On the contrary, the PPI recommends to install another 500 MW of oil-fired thermal combustion plants to address peak-load demand.

# 6 Regulatory Environment

France has been rather reluctant in implementing the EU directives on deregulation of the electricity market (and the gas market as well). The EU Directives on rules for the internal market (96/92 and 2003/54) were not transposed into French law until the 2000 act governing the public electricity service, followed in 2004 by the Act governing electricity and gas companies and 2006 by the Act governing the energy sector (DGEMP, 2006a). As a result, it was no longer possible to run EdF as a nationalized monopolist, instead it was converted into a public limited company (Électricité de France S.A.) with at least 70 % of capital controlled by government. In 1996, EdF's capital stock of 911 mio € is held by the French state (87.3 %), its employees (1.9 %) and other investors (EdF, 2007b). Other consequences were various steps to open up the previously closed French market for other competitors, although power generation is still under ministerial authorization. These steps are described in more detail in section 8.1.

## 6.1 Most Important Subsidies and Policies

Basically, France offers a feed-in tariff system for electricity from renewable energies and co-generation. This has been settled in the law n° 2000-108 of February 10, 2000, while actual tariffs have undergone several changes since then. Regulations for new installations are as follows (DGEMP, 2007b):

**Hydro power** receives 6.07 Eurocent per kilowatt-hour (c€/kWh) plus additional 0.5–2.5 c€/kWh for small installations, plus additional 0–1.68 c€/kWh in winter depending on the regularity of production. Contract duration is 20 years (decree of March 1, 2007).

**Biogas/Methanation** receives between 7.5 and 9 c€/kWh depending on capacity, plus additional 0–3 c€/kWh depending on energetic efficiency. Methanation receives a surplus of 2 c€/kWh. Contract duration is 15 years (decree of July 10, 2006).

**Onshore Wind** receives 8.2 c€/kWh for 10 year, and 2.8–8.2 c€/kWh for the following 5 years, depending on the availability of the site (decree of July 10, 2006).

**Offshore Wind** receives 13 c€/kWh for 10 years, and 3–13 c€/kWh for the following 10 years, depending on the availability of the site (decree of July 10, 2006).

**Photovoltaic power** in continental[6] France is paid 30 c€/kWh, plus additional 25 c€/kWh if the PV modules are an integral part of the building ("prime d'integration au bâti")[7]. Contract duration is 20 years (decree of July 10, 2006).

**Geothermal power** in continental France is paid 12 c€/kWh, plus 0–3 c€/kWh depending on energetic efficiency. Contract duration is 15 years (decree of July 10, 2006).

[6] Different tariffs hold for Corsica and overseas departments.
[7] Note that without this premium the PV price is quite low compared to European standards.

**Cogeneration** receives between 6.1 and 9.15 c€/kWh, depending on the price of gas, availability and capacity. Contract duration is 15 years (decree of July 31, 2001).

The distribution network operator are obliged to buy the electricity produced by those plants (see section 8).

So far, I have found no estimates on the amount of money paid by the feed-in tariffs. Likewise, nothing was to be found with respect to effects on electricity prices. Given the small amount of renewables other than large hydro, these can probably be neglected at this point in time.

The effect on investments and generation mix so far has been relatively small – the French energy mix did not change very much in favor of renewables. In fact, despite an increase in absolute generation, the share of RES in national output actually dropped between 1997 and 2003 (Ragwitz et al., 2005). According to this study, the main reasons for the slow progress are administrative and regulative barriers (mostly at the regional/department level), as well as the grid connection rules, where a large number of administrative procedures is necessary to get a project approved (Ragwitz et al., 2005). As of today it is not finally clear if the changed and in part (PV) significantly increased feed-in tariffs will change these negative assessments.

There are no plans for a nuclear phase-out in France (except probably by some environmental NGOs...).

# 7 Manufacturing and Generation of RES Electricity

On this issue, data acquisition turned out to very difficult. In fact, no information could be obtained so far for the classical renewables (wind, solar, biomass), which still have very little market share in France. Most of these have been transferred from EdF to its subsidiary EdF-EN (EdF-Énergies Nouvelles), but they invest globally and appear not to offer data for France alone.

Hydro power is run by three major producers: EdF-EN, CNR, SHEM (see section 8). There do exist several smaller hydro power producers, which in 2002 produced 0.6% (or about 3 TWh) of output (IEA, 2004).

# 8 Market Structure

EdF is still the main operator for production and distribution. It owns and operates all nuclear and part of the fossil-fuel fired and hydro-power plants. In 2006, it worked an installed capacity of 98.19 GW, or 84.6 % of national capacity, of which 63.13 GW (100 %) are nuclear, 20.44 GW (81 %) hydro and 14.62 GW (53 %) fossil-fired (EdF 2007b). Generation in 2006 was 490.80 TWh of which 428.10 TWh were nuclear, 21.10 TWh fossil-fired and 41.60 TWh hydro (EdF 2007b).

In 2004, other suppliers generated 110 TWh or about 20 % of the French electricity. The main other operators are

- Electrabel, a Belgium-based company belonging to the SUEZ multinational group. In 2006, total capacity of Electrabel France was 4.8 GW, with a production of 12 TWh. Included in these figures is the production of two French companies:

  - CNR (Compagnie Nationale du Rhône, 14.9 TWh production in 2006, 2937 MWe installed), which operates most of the hydro plants along the Rhône river. Electrabel holds 49.98 % of CNR's shares (Electrabel, 2007a).
  - SHEM (Société Hydroélectrique du Midi, 773 MWe, peak-load production), a subsidiary of the national railway company SNCF now held at 99.6 % by Electrabel (Electrabel, 2007b).

  Electrabel also holds production shares at the nuclear power plants in Chooz B (750 MW share) and Tricastin (480 MW share) plants (Suez/Electrabel, 2005; iepf.org, 2004).

- Endesa France (formerly SNET): 2 474 MWe installed capacity in France, 9.5TWh produced in 2004 with coal-fired plants. The Spanish TNC Endesa holds 65 % of Endesa France. (SNET, 2007)

Besides these large companies there exist a number of usually very small producers, that often produce only for their own needs (e.g. companies or small industries). These "autoproducers" mostly run back-up or combined heat and power production units (IEA, 2004) and provide about 4 % of national output (NRG 105a). In 2004, about 42 TWh have also been produced in virtual power plants (VPP), i.e. collectively controlled small and micro plants (Meritet, 2006). VPPs allow smaller providers to meet peak demands of their (often industrial) customers, and are thus a main element in opening the French electricity market (CRE, 2006:52).

Transmission is organized by RTE (Réseau de transport d'électricitéé) EDF Transport, which started out as an independent entity within EdF after 2000 and was transferred into a 100 % subsidiary on January 1, 2006. In 2006, RTE operated some 100,00 km of high- and ultra-high-voltage lines within France and 44 cross-border lines (EdF 2007b).

Distribution is organized as a geographical monopoly, with concessions granted by local authorities. Besides RTE, to which EdF has transferred its distribution activities in early 2007 and who is responsible for 95 % of electricity distribution, there are about 160 distribution companies under municipal or joint ownership. (DGEMP, 2007d,e)

Both transmission and distribution are regulated by the independent regulatory authority, CRE (Commission de Régulation de l'Électricité) to guarantee equal access and competition to all market players. According to this authority, the market is currently actually concurrential (IAEA CNPP, 2004)

## 8.1 Market Liberalization

Market liberalization in France happened in 4 stages (CRE, 2007a,b):

1. In **June 2000**, customers with annual demand $\geq$ 16 GWh were allowed to select their supplier. This affected about 1300 sites or 30 % of total demand.

2. In **February 2003**, this threshold was reduced to 7 GWh/year. By then, the market was open to 3500 sites or 34 % of total demand.

3. In **July 2004**, all non-household customers were included in the liberalized market, which doubled in size to 70 % of total demand on 4.5 mio sites.

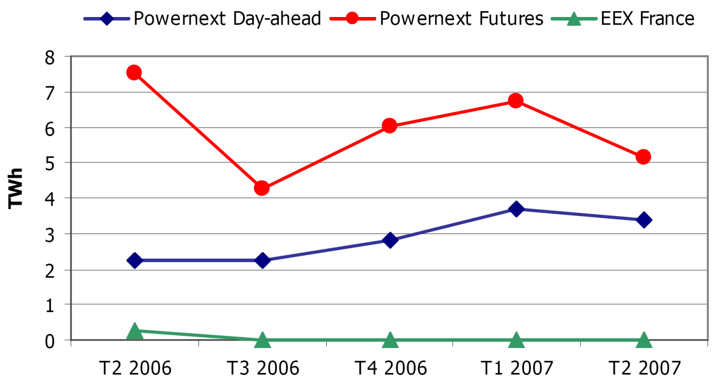
4. On **July 2, 2007** free market access was granted to all customers, affecting over 30 mio sites in France.

At the end of June 2007 there were 17 alternative providers operating, as compared to about 160 historical providers. About 17 % of non-residential customers have chosen to switch from a regulated tariff (proposed only by the historical utilities) to a market tariff. However, only 6.8 % have also changed the provider, the other 10.3 % stayed with their historical provider (CRE, 2007b). Data for household customers will not be available until December 2007.

## 8.2 Market prices

Powernext operates as France's electricity exchange. The company was incorporated in July 2001 with the launch of the first day-ahead product in November 2001. Its capital is divided up among some of Europe's major electricity and financial market participants, including RTE, Euronext, BNP Paribas and EDF (IEA, 2004).

**Figure 8:** Monthly transaction volumes on French organized markets, quarterly averaged (T=trimestre).
Source: CRE 2007b

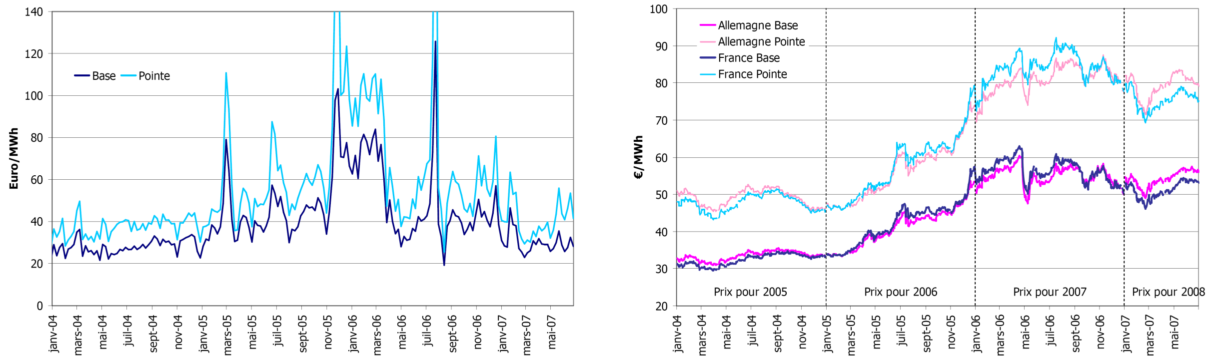



Average monthly trading volumes at Powernext between mid-2006 and mid-2007 have varied between 4 and 7.7 TWh on the futures market[8] and increased from 2 to some 3.5 TWh on the spot market (see Figure 8). This means that 10 % of national consumption (or 8 % of national production, respectively) are being traded on the spot market. In 2006, the Germany-based European Energy Exchange (EEX) offered contracts to be delivered in France, but these are no longer traded. Instead, Powernext and EEX are currently negotiating a merger, initially for the spot market, which will probably be completed in October 2007 (Platts.com, 2007)

During the second quarter 2007, spot prices at Powernext averaged at 29.35 €/MWh for the base price, which is 21 % less than one year ago (see Figure 9, left). The peak price averaged at 41.79 €/MWh, or 17 % less than one year ago (CRE, 2007b). Since 2004, spot base price evolution and levels at Powernext were relatively close to that at the EEX. In contrast to that, the future prices show greater divergence from the German prices. Throughout 2007, French one-year (Y+1) future prices remained below those in Germany, whereas they were higher from mid-2005 until late 2006. Both future peak and base prices have declined from their all-time high in 2006 to 53 €/MWh for base and 76 €/MWh for peak futures (see Figure 9, right).

[8] Note that future markets allow settling by cash or actual physical delivery, so that trading volumes are typically much greater than on spot markets, where only physical delivery is possible.

**Figure 9:** Prices at Powernext 2004-2007. Left: Spot prices. Right: Future (Y+1) prices, German EEX prices included for comparison.
Source: CRE 2007b

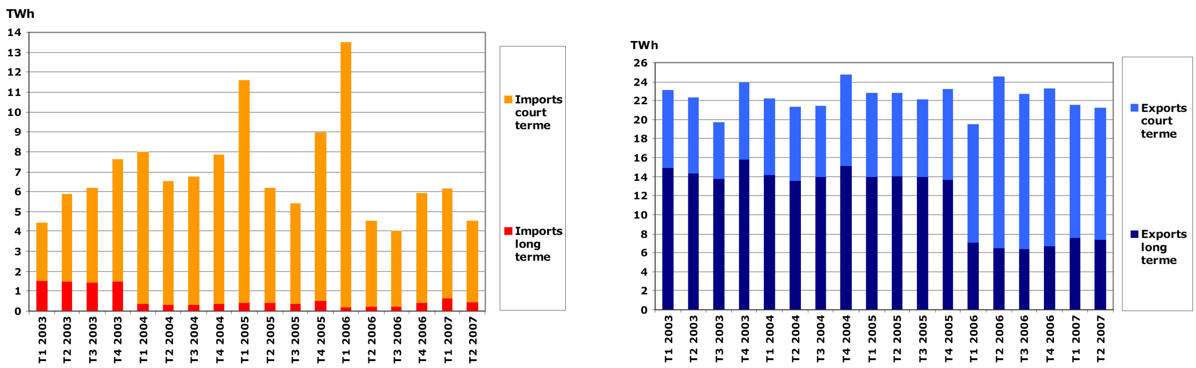



## 8.3 Imports and Exports

There appears to exist a difference between physical imports/exports and contractual imports/exports (RTE, 2007). The numbers here refer to contractual imports/exports, while the data provided by Eurostat (NRG 105a) report physical exchanges. Contractual echanges currently are four times greater than physical exchanges.

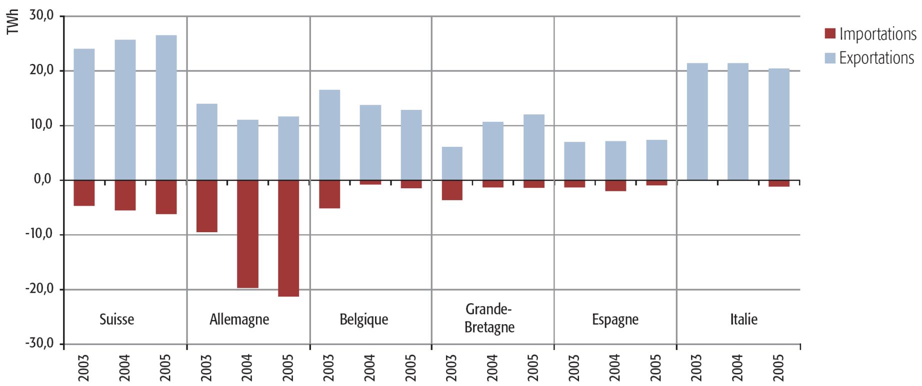
Imports have started to increase since the opening of the electricity market (see Figure 10, left, and compare to Figure 3). Imports typically peak in the first quarter, which is the peak demand season in France, while the average imports are in the order of 3-5 % of French national production. The fraction of short-term imports shows that these imports are mostly used to satisfy peak load gaps. Exports, on the other hand show much less variability (Figure 10, right), and make up some 15 % of national production. Apparently, a number of long-term export contracts have not been prolonged, as can be seen by the drop in the share of long-term exports in 2006.

**Figure 10:** Quarterly sum of electricity imports to and exports from France. Short-term imports/exports are shown in lighter color.
Source: CRE 2007b




Although still being a net electricity exporter, it appears as if France is no longer a "structural exporter" (CRE 2006:54). In 2004 and 2005, France even became a net importer from Germany, and for the first time ever imported electricity from Italy (Figure 11). The reason is that, on the liberalized market, actors increasingly buy from foreign markets in order to benefit from price differentials (CRE, 2006).

**Figure 11:** French electricity imports and exports to neighbouring countries, 2003-2005.
Source: CRE, 2006




# 9 Networks

The French transmission operator RTE is a member of the UCTE (Union for the Co-ordination of Transmission of Electricity), a TSO (Transmission System Operator) which coordinates the high-voltage networks in western Europe. Via UCTE, RTE is also a member of ETSO, the association of European TSOs. Total net boundary transmission capacities are 11700 GW (Spain: 1200 GW, Belgium: 2700 GW, Germany: 2400 GW, Switzerland: 3000 GW, Italy: 2400 GW) (ETSO, 2007).

The French energy system is particularly characterized by a high degree of electric heating (DGEMP, 2006b) – a consequence of nuclear overcapacities. Its demand is thus very sensitive to winter temperatures. In contrast to that, the neighboring German system has a high degree of fluctuating wind power. As a result, imports and exports across the French-German border are highly fluctuating.

I was not able to find any data on cost estimates and/or limitations for large scale integration of RES into the grid.

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