# WHICH ROLE FOR NUCLEAR POWER IN THE BATTLE AGAINST GLOBAL WARMING ?

*The French perspective*

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**Abstract.** The climatic impact of massive releases of carbon dioxide from the burning of fossil fuels has become a major international issue. Atmospheric $CO_2$ concentration continually increases. At the present rate, it is predicted that by 2040 it will have doubled with respect to its pre-industrial level. In a growing world economy, now dependent on fossil fuels for 90% of its energy, only a drastic change in energy policy involving extensive use of $CO_2$-free energies can make it possible to stabilize atmospheric $CO_2$ levels. With 35% of its primary energy from nuclear reactors, France sets a good example for the greenhouse gas reduction. Using this energy has resulted in a 20% reduction in releases since 1973. During the same period, world emissions have increased by 45%. In view of the French experience in 25 years of managing a large number of nuclear reactors in respecting safety requirements and environmental impact, it appears that nuclear energy has an important role to play in the battle against greenhouse gases.

## 1. INTRODUCTION

The 20$^{th}$ century is characterized by an unprecedented growth of the world economy and the resulting high consumption rate of primary energy. Up to now, this exponentially growing energy demand has been met mainly by fossil fuel burning. Future projections for the world energy consumption forecast a steady rise, whatever economic scenarios may be adopted, and needless to say that growth is strongly connected with world population trends and economical development.

At present, 90% of the world's primary energy production still relies on fossil energy sources, including oil, gas and coal. The amount of $CO_2$ annually released to the atmosphere by human activities (around 7 Gt of carbon) corresponds to the quantity of carbon stored in geological deposits over a million years by natural processes! In the last decade, scientists have shown (IPCC, 1996) that $CO_2$ emissions from this massive consumption of fossil fuels are an environmental hazard and result in a greenhouse effect which threatens the earth's climatic equilibrium.

The conclusion reached by the IPPC experts, despite uncertainties concerning the exact scope of the phenomenon, is that planetary warming is indeed connected with the increase of greenhouse gases, and particularly with the anthropogenic increase of $CO_2$. As a general average, the data provided by the weather networks indicate a warming of 0.6°C since the end of the 19$^{th}$ century. At the same time, the level of the seas has risen by 10 cm, because of the warming of the oceans (thermal expansion) and glacier melting.

For a doubling of $CO_2$, climate models predict an average warming of about 3°C and the figure could reach 12°C at the poles, with a sea level rise of 50 cm threatening thousands of km$^2$ of densely-populated coastal areas. For a tripling of $CO_2$, which can be anticipated for the year 2100 if nothing is done to counter the $CO_2$ increase, the figures are obviously even more alarming.

There is also a suspicion that climatic warming threatens stability of the global ocean circulation, the great climate regulator of western Europe (Rahmstorf, 1995; Stocker and Schmittner, 1997).

We still have only limited knowledge of what will be the actual impact of this global warming. What repercussions will climatic change have on rain and agriculture in the various countries of the world ? What will be the consequences for the frequency of appearance of extreme climatic events such as floods, droughts and storms, and on the economy generally?

A recent example may be given with the exceptionally strong hurricane that swept across Europe on Christmas 1999, for which the damage costs released by the insurance companies are 20 billion francs for France and 100 billion francs for Europe as a whole. The French insurance companies have already announced an increase in premiums for the year 2000. Although this measure was relatively well accepted by public opinion, how long will it remain acceptable if such extreme events are to occur more frequently? Owing to their global nature, future costs of climatic change may exceed by several orders of magnitude the damage cost of any known disaster linked to energy production, transportation or industry (fig.1).

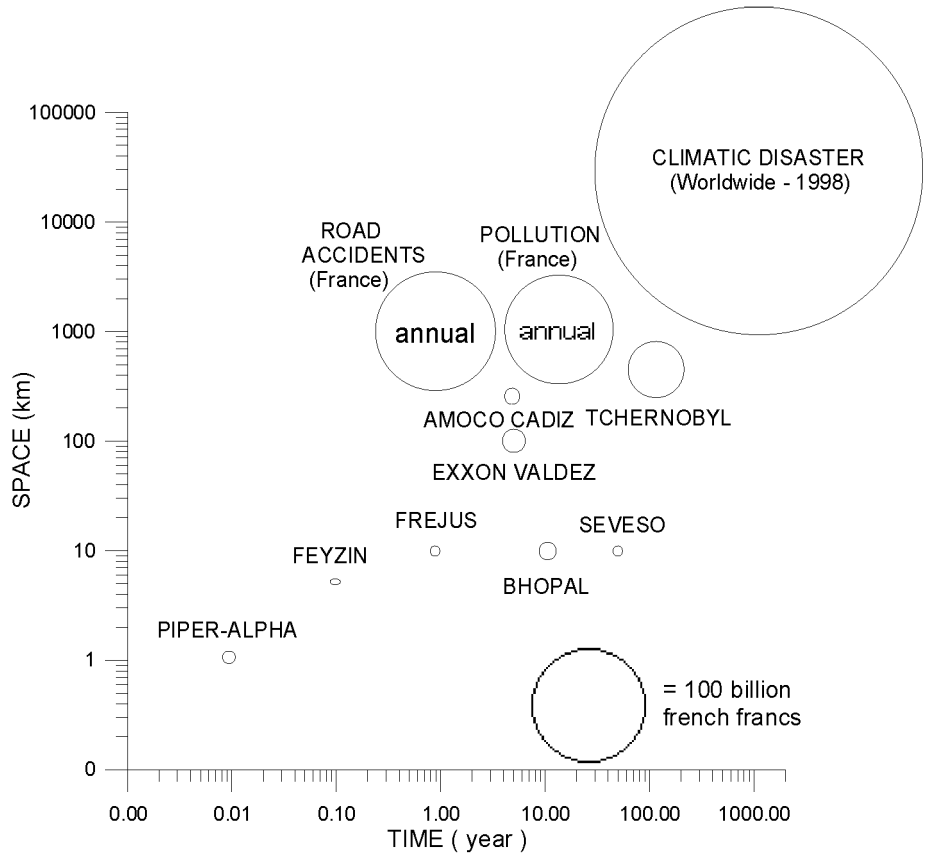


*Figure 1: Space and time severity diagram for energy, industry and climatic related disaster. Circles surface areas are proportional to economic losses (ref.: Ministère de l'Equipement, Ministère de l'Industrie, OECD, www.worldwatch.org)*

If we consider the current imbalance in the energy consumption between industrialized nations and the developing world, the reduction in $CO_2$ emissions and the need of the poorest nations for developing their economy require a massive transition to carbon-free power (Hoffert et al., 1998). Therefore, has the time not come to follow the path of sober growth, relying on the energy efficiency made possible by technical progress and on a diversification of energy sources, particularly by favouring the energies that do not emit $CO_2$?

## 2. LESSONS FROM FRENCH ENERGY POLICY

### 2.1 Nuclear energy

Nuclear energy is a readily available $CO_2$-free energy capable of supplying vast amount of energy.

In the face of the oil crisis in the 1970s, the French government adopted a policy aimed at reducing energy dependence by relying on the development of a modern and safe nuclear sector, respecting the environment. This policy, wrongly characterized as "all-nuclear" by its opponents even though this energy represents only 35% of primary energy consumption, leads to a more balanced distribution of primary energy sources, but nevertheless still with marked domination by fossil fuels (59%), including 39% for oil (fig.2).

With about 100 Mtoe annually produced by the nuclear sector (i.e., a figure equivalent to the annual oil production of Koweit), this policy made it possible to cut energy dependence from 75% in 1973 to 51% in 1999, and to keep the kWh at a low cost that does not react much to market fluctuations.

As far as $CO_2$ emissions are concerned, the use of nuclear energy avoids substantial carbon dioxide emissions. French emissions of $CO_2$ (fig.3) have fallen by approximately 20% since 1973, while the world's emissions were rising by 45%. If all industrial countries had followed a comparable policy, the annual releases of fossil carbon would now be 1 Gt less than they are, a reduction that far exceeds the Kyoto objectives (IAEA, 1997).

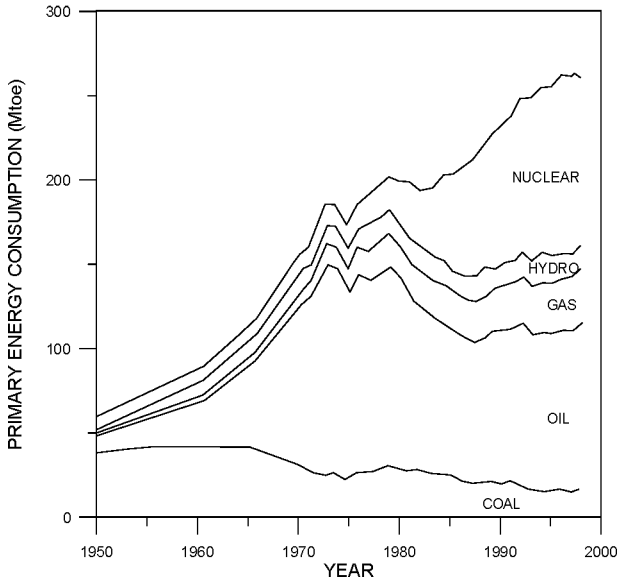


*Figure 2 : Time evolution of the French energy mix (ref. : DGEMP)*

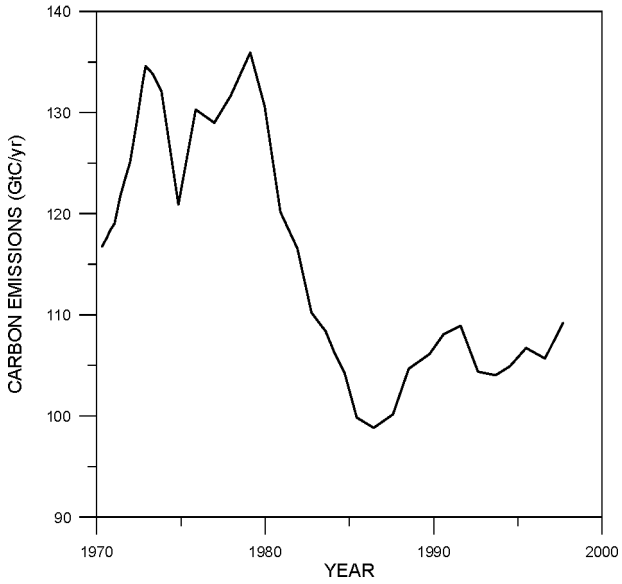


*Figure 3 : Time evolution of the French $CO_2$ emissions (ref. : Obs. de l'Energie)*

Replacement of thermal power stations by nuclear generating plants also reduces air pollution ($SO_2$, NOx and dust). The best example is $SO_2$, whose emissions have fallen by 70% in France since 1980 (IFEN, 1999).

In 1998, France's exports balance with neighboring countries in the electricity sector represented 14.5% of the whole production. These exchanges contribute to the European electricity market as well as to strengthening the security of the electricity network. However, it also points to the contradiction faced by several European governments, who declared a moratorium on nuclear

energy (Spain and Italy, and now Germany) under the pressure of their public opinions, but who can cover their actual needs only with importing nuclear electricity (fig.4).

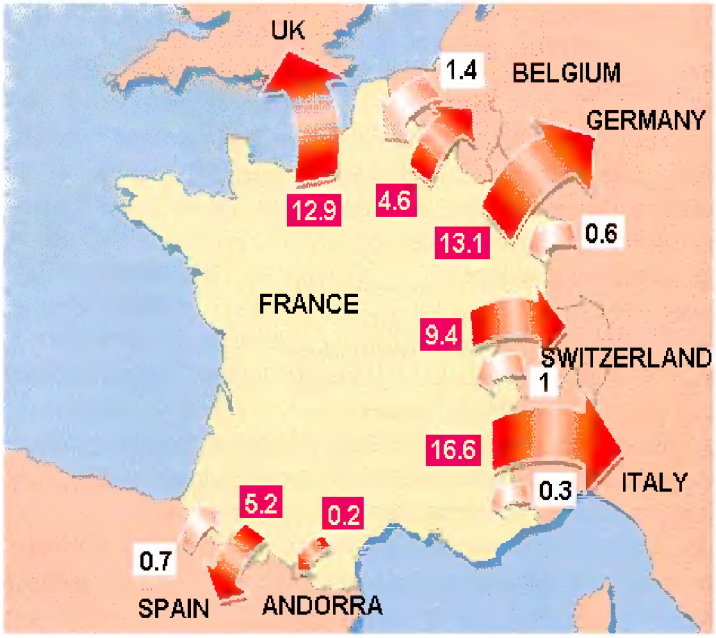


*Figure 4 : Electricity exchanges in TWh (ref. : EDF)*

### 2.2 Renewable energies

Renewable energies, including wind and solar energies, will certainly play a significant role in the future energy mix, even though their present share of the total energy production is modest and increases only slowly.

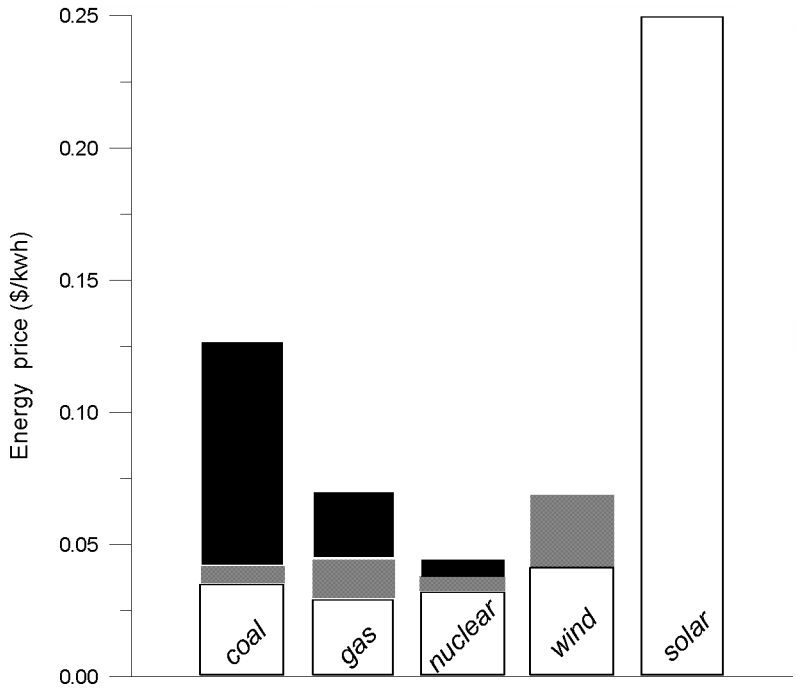


*Figure 5 : Cost of electricity in France (ref. DIGEC, OECD). The grey area accounts for prices fluctuations. The upper dark rectangle corresponds to external costs (ref. European Commission)*

The main problem faced by these energies is that they cannot deliver massive energy amounts as conventional electric power plants can. Moreover, their price is not yet fully competitive on the energy market (fig.5).For several decades, French governments have followed a determined policy with respect to renewable energies, placing France at the first rank in Europe (fig.6). This policy was mainly focused on hydraulic energy. Almost all of the suitable sites for hydraulic energy have now been equipped, including tidal energy, with one of the largest plant in the world (240MW) in operation for more than 30 years on the Brittany coast (La Rance Dam). Therefore, the time has come to develop additional renewable energy sources.

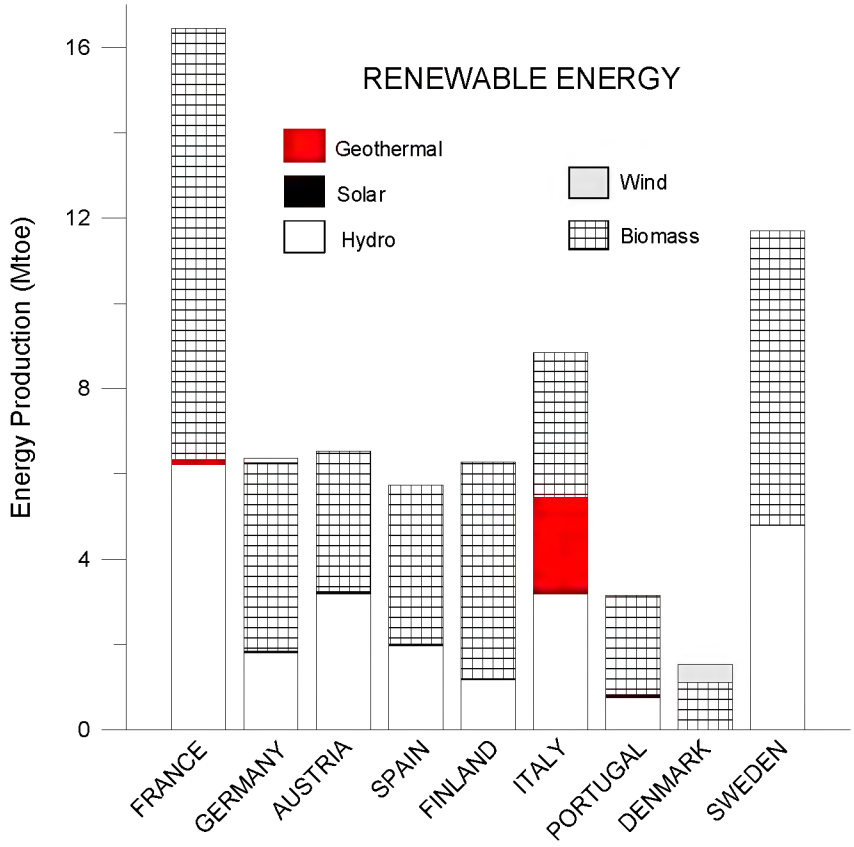


*Figure 6 : Renewable energy production in Europe (ref. : Eurostat)*

Although relatively modest, the EOLE 2005 program is aimed at expanding the French wind energy sector, with an additional 250 MW capacity (i.e., equivalent to a mid-size conventional thermal power plant). Wind turbines are subsidized, with the hope that cost effectiveness will be reached in the near future, at least for the sites that are the most favorable (i.e., along the northern coastline and in the Rhone valley). Installation of individual solar water heaters and solar cells (the HELIOS 2006 project) is also encouraged, especially in the southern part of the country and in the French tropical islands, which are the best suited for this type of energy systems.

## 3. CONCLUSIONS

For France, developing renewable energy sources and maintaining its nuclear energy capacity are central issues for meeting the Kyoto objectives (i.e., the same level of greenhouse gas emissions as in 1990). Nuclear energy is one of the most readily available means of reducing $CO_2$ releases in

appreciable proportions, while awaiting a possible takeover by other energy sources (solar, nuclear fusion, …). Hence, in the battle against global warming, it seems particularly desirable that modern, safe and environmentally friendly nuclear energy sectors be developed in the most technically advanced nations, which are the most capable of operating such energy systems with the highest safety standards.

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