CESSA Conference
13th – 15th December 2007
Judge Business School, University of Cambridge, UK

# Nuclear power – The Swiss experience

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## 1. Introduction

In Switzerland, as in many countries, nuclear power (NP) represents a very controversial issue. Leibstadt was the last nuclear power plant (NPP) built in Switzerland, which was activated in 1983. Today, the biggest electric companies plan to build new NPPs. Authorisation by the Federal Assembly depends notably on the political Centre, which could vote with the Right for, or with the Left against, NP. The final say belongs to the Swiss people; it is very difficult to predict the outcome of a referendum.

Switzerland represents a focal point for the European electric network. Hydropower (HP) represents about 58% of electricity generation; NP 38%; Fossil fuel power (FP) and New renewable (NR) 4%. The creation of two poles is changing the Swiss electricity map, which includes about 900 companies, both privately owned and owned by cantons and towns. The West pole is led by the Groups ATEL and EOS, while the East pole is led by the Axpo Group. In 2006, Earnings before interest and tax (EBIT) of the West pole were 1134 MCHF, while energy sales (ES) 194 TWh; in the case of the East pole, in 2005/06, EBIT were 1411 MCHF and ES 112 TWh[1].

The process of opening the electricity market to competition started in 1998. The Federal Electricity Supply Act was approved by the Federal Assembly on March 23rd, 2007. The Federal Energy Act of June 26th, 1998 was revised on this occasion. These acts provide the legal framework for energy policy, electricity market reorganisation and supply security.

My paper provides an overview of the Swiss NP experience, its history, perspectives and specificities. Risks related to social acceptability, regulation, price and cost evolution, and internalization of external costs, are discussed. Furthermore, convergences and divergences between supply security goals and business targets are analysed.

NP is analyzed in the context of the Swiss electricity supply mix in order to take into consideration all the risks of the electric system and not only those created by NP. We carry out a comparison between nuclear power (NP), Combined Cycle Gas Turbines (CCGTs), which represent the main competitor technology to NP, and Hydropower (HP). On the basis of the studies carried out by the Swiss Federal Office of Energy (OFEN, 2007), we suppose that for a transitional period of some decades New Renewables (NR) and Rational Use of Electricity (RUE) are unable to ensure equilibria between supply and demand. The other relevant documents used to carry out my analysis are quoted in the references.[2]

[1] *Cf.* ATEL, Axpo and EOS *Geschäftsberichte.* 1 CHF=0.6 Euro=0.4 £ (1.7.2007).

[2] For their comments, I would like to thank Dr William J. Nuttall, Judge Business School, University of Cambridge, as well as an anonymous referee.

## 2. Energy policy

In 1945, the Swiss government created a commission to coordinate studies on nuclear energy. The project to design a Swiss reactor was abandoned after an accident which occurred at the experimental NPP at Lucens in January 1969, which left no victims, but resulted in a core meltdown.

In the Sixties, the government and the electricity sector banked on NP to deal with the exhaustion of hydroelectric potential, as well as to limit air pollution, provoked by fossil fuel combustion. The NPPs of Beznau and Mühleberg were built. Beznau included two Pressurized Water Reactors (PWR) of 350 MWe each (today 365 MWe), whilst Mühleberg included one Boiling Water Reactor (BWR) of 355 MWe. Antinuclear opposition was almost non-inexistent.

In the Seventies-Eighties, we find the same approach: NP is seen to contribute to supply security and air quality, following the oil shocks and the acid rain problem. At stake is the substitution of oil by electricity. However, we note the rise of antinuclear opposition, increasingly so following Three Mile Island and Tchernobyl. Doubts are expressed about the credibility of the Swiss Confederation's bodies and experts in the field of NP, because of their adhesion to the nuclear paradigm. Gösgen and Leibstadt are built, whereas the Kaiseraugst project is abandoned in 1988. For Gösgen, the investors opt for a 940 MWe PWR (today 970 MWe), while for Leibstadt they choose a 990 MWe BWR (today 1165 MWe). Long term contracts are made with French NPPs.

1990 represents a turning point. The people accept the Constitutional article on energy. The government can implement a much more active energy policy. Furthermore, following a popular initiative, a NP phase out is rejected, but a 10 year moratorium is accepted. At that time, the electricity sector itself expresses doubts on the future of NP, because of the opening of the electricity market to competition, as well as consumption growth which is clearly lower than anticipated. The Swiss government authorizes the NPPs' power uprate, despite antinuclear protest.

Today Switzerland wonders how it will replace NPPs and long term contracts abroad (LTCs) that are reaching their end. The government proposes the development of NR, the promotion of RUE, and the construction of 1 or 2 new NPPs and/or several CCGTs. In general, NP is contested by the Left and gas by the Right. On May 18th 2003, the Swiss people reject the renewal of nuclear moratoria. However, from here the referendum battle was won, opening a nuclear site, the road is long…

## 3. Institutions

The decisions concerning NP are centralized by the Confederation and are based on an authorisation system. This principle is developed by the Federal Atomic Energy Act of February 21st 2003, first adopted in 1959. In contrast, in the case of HP and FFP, decisions are decentralized to cantons and municipalities. The Federal Hydropower Act of December 22nd 1916, defines the system of water concessions, which determine the rights and obligations of the electric companies. There are no specific Acts concerning FFPs.

The construction of a NPP requires "general authorisation", granted by the Federal Council (the Swiss government), which must be ratified by the Federal Assembly. This decision is subject to a facultative referendum, which is organized if 50000 signatures are collected. Furthermore, the Federal Department of the Environment, Transport, Energy and Communications has to grant "construction and exploitation authorisation".

Several cantonal constitutions force authorities to oppose the construction of nuclear installations. The Federal Atomic Energy Act states that cantonal laws are taken into account in the measure that they don't impede construction projects in a disproportional manner. The canton can appeal if the federal department gives consent despite its opposition.

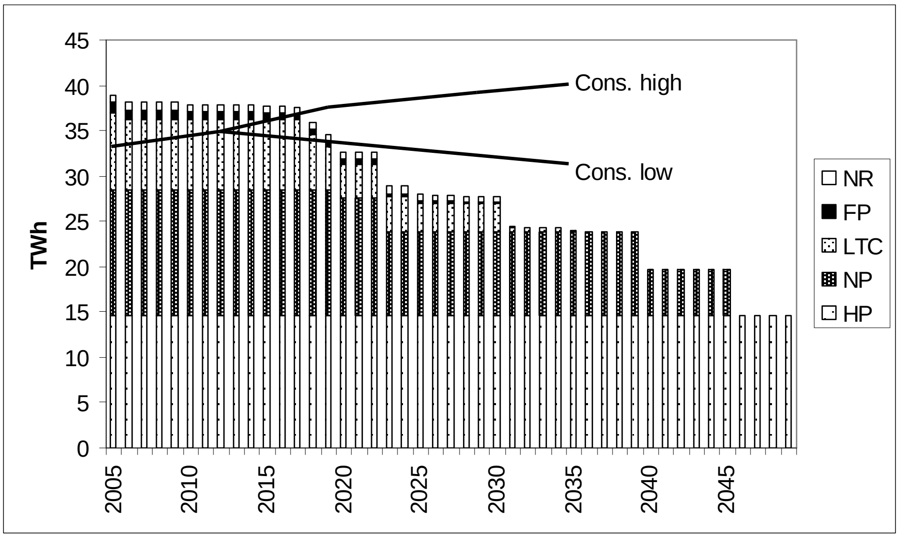
Concerning safety and surveillance, the Federal Act states that “Nobody can give technical instructions to supervisory bodies, who are formally separate to the authorities responsible for granting authorisation” (art. 7/2).

## 4. Electricity supply

Figure 1 shows the gap between demand and supply for the winter semester if no new investments are carried out. The curves represent the highest and the lowest scenarios of the demand for 2005-2035. The histograms show supply and its origin for 2005-2050. One can easily detect the closure of NPPs, as well as the end of LTCs abroad.

One should stress that NPPs provide base load energy[3], while HP provides intermediate, peak and super-peak energy. In general, imports take place at night and provide energy to hydro pumps, while exports occur during peak and super-peak hours. The integration of these different supply sources allows the electric system’s optimization, as well as the valorisation of hydro reservoirs’ water, which represents Switzerland’s comparative advantage. However, international trade is limited by bottlenecks on networks. Furthermore, in the case of the LTCs abroad, a new problem is represented by transportation conditions, following the adoption of the principle of Third Party Access. The fact that in 2005 the balance on international trade was for the first time negative (-6350 GWh) is considered by electric companies as an indicator that new sources of base load energy should be created to keep an appropriate security margin in this supply segment.

Figure 1 – Electricity supply and demand, with no new investments, winter semester, 2005 – 2035 – 2050.




Source: Swiss Federal Office of Energy (OFEN, 2007, p. R-10).

## 5. Generating costs

Figure 2 shows the generating costs of existing power plants, the Leibstadt NPP, the French NPP of Cattenom, where a Swiss consortium has a participation, as well as the HPP of Blenio. Until 1995, Leibstadt generating costs were very high. At that time, in view of the opening of the electricity market to competition, one thought that it was a stranded investment.

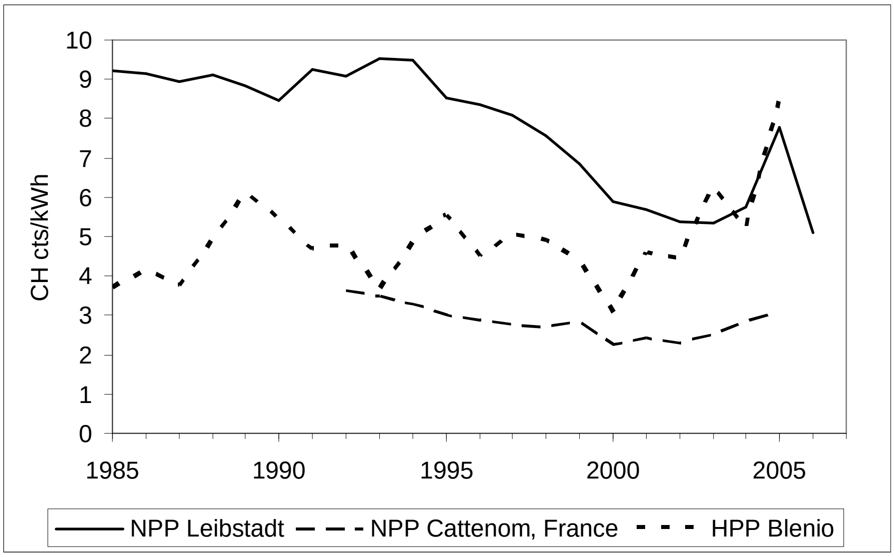
[3] *Cf.* Pouret L., Nuttall W.J. (2007).

Since then, we notice a quite strong cost reduction, which reflects the increase in capacity and generation, the power plant life extension, and the reduction of all cost categories, with the exception of personnel and provisions for decommissioning, as depicted by figure 3. More precisely, in the period 1990/94, the average cost was 9.2 CH cts/kWh, whereas in the years 2000/04, 5.6 CH cts/kWh. This figure also shows the relative weight of the different cost categories for the average years 1993/94 and 2003/04.

The peak shown by figure 1 with regards to the 2005 Leibstadt generating cost is due to a technical outage, which resulted in a 5 month shutdown of the NPP.

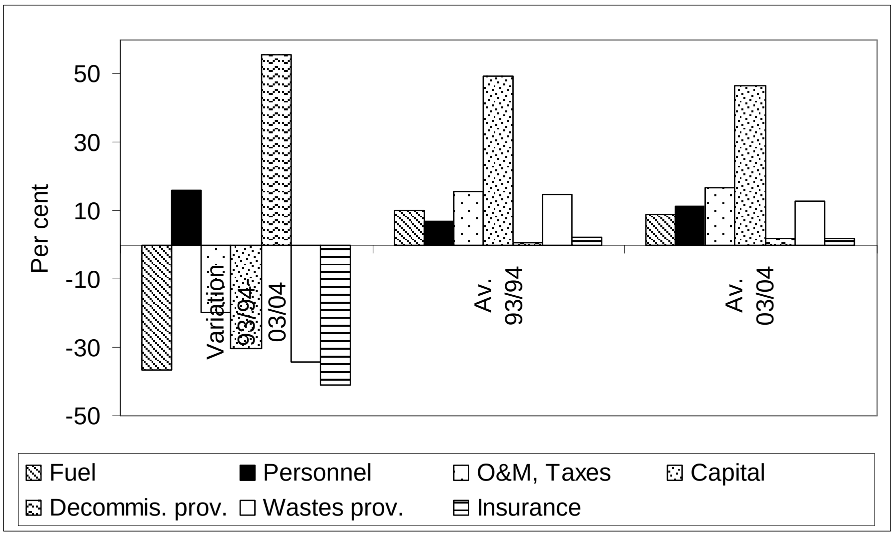
The Cattenom generating costs are much lower. Concerning the Blenio HP plant, we notice the fluctuations due to seasonal precipitations. The peak of 2005 was provoked by a drought.

Figure 2 – Generating costs of existing nuclear and hydro power plants.




Sources: *Leibstadt* and *Blenio Geschäftsberichte.*

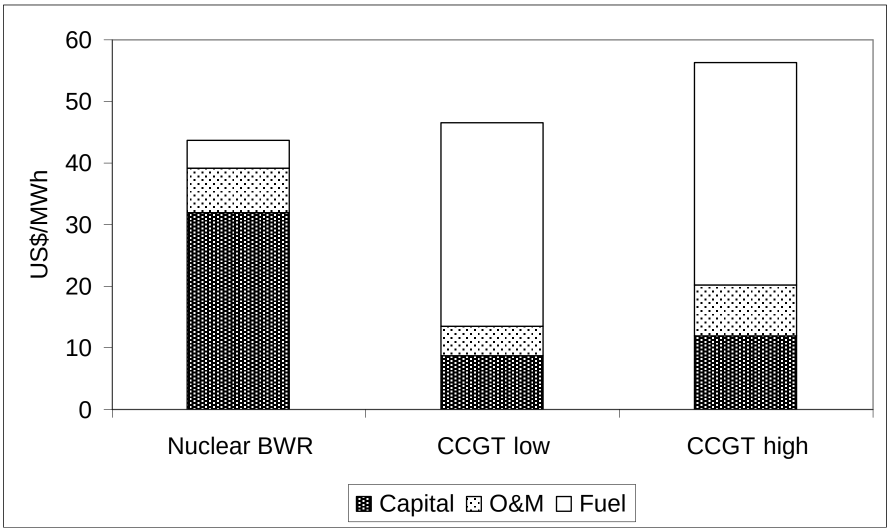
Figure 3 – Leibstadt NPP generating costs.




Sources: *Leibstadt Geschäftsberichte*.

Finally, figure 4 shows the projected generating costs of NPPs and CCGTs, which could be built in Switzerland in the foreseeable future. These estimations are carried out by the Nuclear Energy Agency and the International Energy Agency. They should only be used with great caution, because they are drawn from "paper and pencil studies", rather than from actual experience, and because the estimations of these agencies have always been biased by a favourable attitude toward NP[4].

Figure 4 – Projected generating costs, Switzerland (*).




(*) Decommissioning, waste disposal, insurance included; taxes and duties not included; discount rate 10%; gas price rate of growth: 1.9%/yr; capacity: NPP 1600 MWe; CCGT 100 MWe (high cost) and 400 MWe (low cost).
Source: NEA/IEA, 2005.

## 6. Nuclear power competitiveness

One can quote six factors that influence NP competitiveness:

- Regulatory stability and licensing processes: The antinuclear opposition will try to take advantage of all opportunities offered by regulation in order to create obstacles to NP projects. The time required between general authorisation and NPP activation is 16-18 years according to federal authorities, and 12-15 years according to the electricity sector.
- Efficient management (during construction and operation): One should recognize that cost control is difficult in the nuclear industry and uncertainties remain high, as reconfirmed by the recent experience with Olkiluoto 3 in Finland[5].
- Conditions of appropriate financing: Financing large power plants is facilitated if the Swiss model of "partner companies" is adopted. As each partner absorbs the production, and covers generation costs, in proportion to its share of the investment, the risk is shared between them. In this respect, one should also mention the financial

[4] *Cf.* Romerio F. (1998).
[5] *Cf.* Beutier D. (2007).

solidity of such companies as ATEL and Axpo, as well as the financial guarantee indirectly provided by public companies[6].

- Stability of sale prices: Long term contract should be created to overcome the problems related to market price volatility and capital intensive investments. These contracts can be facilitated by a certain degree of integration between generation and supply, as in the case of ATEL and Axpo.
- The CCGTs alternative: The advantage of this technology is the relatively short payback period and flexibility, notably the staged investment option. If an outlet is found for heat, its comparative advantage increases. The disadvantage is the gas geopolitics and the fact that gas market remains insufficiently open to competition, particularly in Switzerland, so much so that gas prices continue to be indexed on oil prices.
- Climate policies: Placing a significant "price" on $CO_2$ emissions gives an advantage to NP. The measures taken in Switzerland follow this trend. For instance, gas power plants have to compensate for $CO_2$ emissions, for which at least 70% in Switzerland, abatement costs are higher.

## 7. Investments

Electric companies are willing to invest for two reasons: To do business and to diversity the portfolio, which also means satisfying customer expectations and complying with regulation on supply security. Concerning business, one should point out that the net benefit of the Swiss companies which are at the origin of 95% of electricity generation, was MCHF 1655 in 2005, and the balance on international trade MCHF 737[7].

In fact, electric companies have medium and long term strategies. They are not only led by short term market fluctuations. As pointed out by David Newbery, "… large irreversible investment decisions are based on analysing market fundamentals, not just current trading views…"[8]. In this perspective, investments with long payback periods can be preferred.

The fact that electric companies opt for NP, with the exception of the companies belonging to "antinuclear cantons", is due to the traditionally favourable attitude towards this technology, as is also the case for HP. Furthermore, they probably tend to under-estimate nuclear economic risks and over-estimate economic risks related to gas.

Table 1 – which is self explicatory – shows the investments envisaged by the electric sector for the period 2008-2035. The new NPPs belong to generation III.

Table 1 – Investments envisaged by the electric sector.

| | TWh | 1000 MCHF |
|---|---|---|
| Nuclear | 20 | 10-12 |
| CCGTs | 3 | 2 |
| Renewable | 5 | 8-10 |
| Hydro pumps | (super-peak) | 3 |
| Networks | (to avoid bottlenecks) | 2-3 |
| Total | 28 | 25-30 |

[6] Simon Taylor, Judge Business School, Cambridge University, is preparing a CeSSA paper on the problems related to finance.
[7] Despite the fact that in physical terms the balance was negative in 2005. *Cf. Statistique Suisse de l'électricité,* 2006.
[8] Newbery D (2005), p. 10.

Source: G. Leonardi, CEO ATEL, in Ferraz C. and Romerio F., 2007.

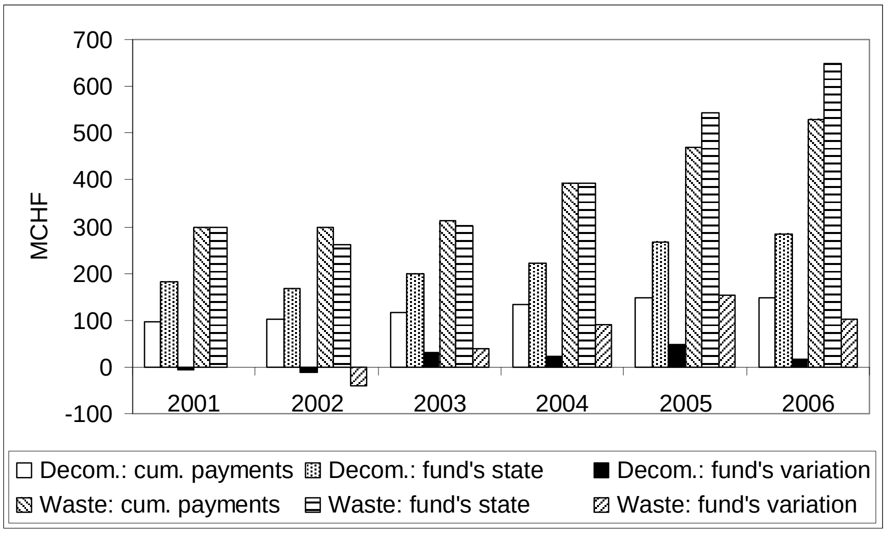
## 8. Radioactive waste disposal, plant decommissioning and insurances

One should stress that the Federal Atomic Energy Act states that “The general authorisation [concerning a new NPP] may be granted... if it is demonstrated that radioactive waste will be disposed of” (art. 13/1.d). The creation of a nuclear deposit to a repository requires the authorisation of the Federal Assembly. The host canton is associated to the project; it can appeal against an authorisation of construction or exploitation. The projects that are envisaged by the National Cooperative for the Disposal of Radioactive Waste (NAGRA) could be jeopardize by local populations, who have shown little willingness to accept this kind of burden.

In principle, waste disposal and power plant decommissioning costs are covered by special funds managed by the Confederation, to which NPP owners contribute. These contributions are re-evaluated periodically. One supposes a lifespan of 40 years for NPPs.

Figure 5 shows the Leibstadt NPP waste disposal and decommissioning provisions. The cumulated payments, the state of the funds and their variations are highlighted since 2001. In 2006, the decommissioning fund was MCHF 280, while the waste disposal fund MCHF 650. The figure also shows losses in 2001 and 2002, which raises the problem of the funds' return. In 2003/04, these payments represented about 15% of Leibstadt's generating costs.

Figure 5 – Leibstadt NPP, waste disposal and decommissioning provisions: Cumulated payments, funds' state and variations.




Sources: Stilllegungsfonds und Entsorgungsfonds: Jahresrechnungen.

The owners of NPPs have to take out private insurance and insurance from the Confederation. The private insurance coverage is MCHF 300, while the Confederation's cover is MCHF 1000, as far as damages exceed the sum covered by the private insurer. One should point out that such an insurance system does not exist for HPPs and FPPs. In 2003/04, insurance costs represented about 2% of the Leibstadt's generating costs.

## 9. Conclusion

Public acceptability represents the main obstacle to a “nuclear revival” in Switzerland. NP remains highly controversial. As the risks cannot be eliminated completely, for opponents they will never be low enough. Supporters must show that an appropriate solution exists for radioactive waste. There is a risk that the debate slides into demagogy, creating a positive or negative opinion towards NP, and also that a “butterfly’s wings” in a Japanese NPP or at Gazprom strongly conditions the outcome of a referendum.

To overcome the gridlocks, a “Swiss compromise” on an ambitious and efficient energy policy program, and on a well balanced energy mix, should be created. We should however recognize that in this respect political willingness is low. From my point of view, NP should be considered as an “energy of transition”, which can play a significant role in supply security, but should be abandoned towards the end of the century, when technological progress in new renewable energy and changes in lifestyle allow it.

The economic obstacles are not insurmountable, but risks shouldn’t be underestimated. Electric companies must be very determined and must implement excellent management to succeed in building new efficient NPPs.

The study of the Swiss case seems to show that the market works in relation to electricity supply security. Despite the opening of the market to competition, the willingness to invest in different technologies, including base-load NPPs and super-peak HPPs, exists in Switzerland. In this respect, one can state that there are no significant divergences between supply security goals and business targets. However, one should recognize that the perfectly competitive market supposed by many models does not exist. The conditions of deployment of NP, HP, FP, in particular the political, institutional and business aspects represent a good illustration of the world as we know it in Switzerland.

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*This paper is based upon work presented at a conference held at Judge Business School, University of Cambridge from 13-15 December 2007 and sponsored by the European Commission Sixth Framework programme project CESSA - Co-ordinating Energy Security in Supply Activities - EC DG Research contract number 044383.*

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## Abbreviations

| | |
|---|---|
| BWR | Boiling Water Reactor |
| CCGTs | Combined Cycles Gas Turbines |
| FP | Fossil fuel power |
| FPPs | Fossil fuel power plants |
| HP | Hydropower |
| HPPs | Hydropower plants |
| LTCs | Long term contracts |
| NP | Nuclear power |
| NPPs | Nuclear power plants |
| NR | New renewable energy |
| PWR | Pressurized Water Reactor |
| RUE | Rational use of electricity |