Key messages and issues
ECONOMIC SUSTAINABILITY OF NUCLEAR POWER

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BACKGROUND

Economic sustainability is a condition which nuclear power will have to meet at all times if it is to contribute substantially to the reduction of greenhouse gas emissions. The analysis of this topic involves several aspects such as the generation cost structure -the relative weights of capital investment and running expenses-, the costs of other alternatives to produce electricity, the prospects and trends of the future costs of equipment and construction services as well as of fuel prices, the costs of extending service life, the effect of liberalizing the electricity supply industry, the costs of keeping a high level of nuclear safety, etc.

Having carried out this analysis, the main points and conclusions are presented in this paper, identifying a number of key issues which are critical for the long-term viability of nuclear power.

KEY MESSAGES

(1) Nuclear power is capital intensive. The capital cost of a nuclear power plant (including equipment, engineering and construction services and interest during construction) ranges from $ 1,500/kW to $ 3,000/kW. The relative contribution to total cost of the three generation components of a typical 1,000 MW nuclear plant might be as follows for a capacity factor of 80% (7,000 hours per year at full power) and a lifetime of 25 years, assuming a capital cost of $ 2,250/kW and a discount rate of 5%:

* Capital	2.28 ¢/kWh	63%
* O&M	0.90 ¢/kWh	25%
* Fuel	0.45 ¢/kWh (*)	12%
Total	3.63 ¢/kWh (**)	100%

(*) Waste Disposal and Dismantling not included. Typical value: 0.20 ¢/kWh.
(**) On-going capital investments not included.

The cost uncertainties are associated with the construction period (5 to 10 years). Fuel is cheap, so there is minor uncertainty during the operating cycle (25 to 40 years).

Several factors, such as the number of plants, standardization and regulatory environment, affect the relative costs of nuclear compared to other sources. This results in a large variability between countries.

(2) Gas-fired combined-cycle plants are fuel intensive. Capital cost ranges from $ 400/kW to $ 800/kW. Relative contributions to the total cost of a typical 400 MW gas-fired plant for a capacity factor of 80% and a lifetime of 20 years, assuming a capital cost of $ 600/kW and a discount rate of 5%, are as follows:

* Capital	0.69 ¢/kWh	18%
* O&M	0.45 ¢/kWh	14%
* Fuel	2.20 ¢/kWh (*)	68%
Total	3.34 ¢/kWh (**)	100%

(*) Assuming 1.20 ¢/Thermie (3 US$/G joule) and a heat rate of 1.80 Thermie/kWh.
(**) On-going capital investment not included.

There is small uncertainty for cost overruns during the construction period (3 years). The cost uncertainty is associated with the medium and long-term evolution of the gas market during the operating cycle of the plants (20-30 years).

(3) High sensitivity of nuclear power to the discount rate. The long construction schedules and the high costs of equipment and services make nuclear power very sensitive to the discount rate, i.e., the cost of the financial resources employed during construction. The following table shows the sensitivity of total generation costs of nuclear and gas power plants for the same assumptions in (1) and (2):

	3%	5%	8%
Nuclear	-10%	Base	+20%
Gas	-3%	Base	+5%

In other words, the higher the discount rate, the less competitive nuclear power becomes.

(4) The break-even point is about $ 2,000/kW. For a discount rate of 5%, a nuclear construction cost of $ 1,960/kW is the break-even point between nuclear and gas, i.e., the levelized generation costs of nuclear and gas would be the same.

(5) The liberalization of electricity supply is a challenge for nuclear power. The current general world-wide trend towards electricity liberalization means that in some ten years time a substantial part of the world's nuclear power plants will be operating in a competitive environment. The challenge for them is to be competitive with other sources of electricity while maintaining a high level of nuclear safety.

(6) Most of the existing nuclear power plants will be competitive on the free markets on which they will operate due to their low unit production cost. This is nuclear power's main advantage in competing with other sources. As an example, figures quoted for average production costs in the U.S. in 1996 are as follows (in ¢/kWh):

Nuclear	1.91 (*)
Coal	1.83
Gas	3.38
Oil	4.14

(*) Including Waste Disposal and Dismantling.

According to data from various sources, no more than 10% of the 110 US existing reactors have been or will be shutdown due to competitive pressures and none of the 153 in Europe.

(7) Which utilities will be in a better position to compete? In general terms, the nuclear utilities better placed to compete will be those with:

· various NPP's, in order to spread overheads
· a nuclear production unit cost (O&M and fuel) of less than 2 ¢/kWh
· no substantial pending investments
· guaranteed recovery of all or a large portion of the stranded costs and back-end liabilities
· a top management committed to maintaining a high level of safety.

(8) High safety and low cost may go hand in hand. It has been proven that high safety and low cost are not in contradiction to each other as shown in various countries where plants with the best regulatory performance are also the best in economic performance, having the lowest operating unit costs.

(9) The long-term challenge is to be able to build large number of new nuclear power

plants. The average life of the NPP's currently in operation is some 20 years. In the assumption that their service life will be extended to reach 40 years or even longer, these plants might still be in operation around the year 2020 albeit close to their end of life. The real challenge for the nuclear industry is to be able to supply at competitive construction prices (say less than $ 2,000/kW) the large number of new plants which will be needed to replace these NPP's and those which might be built instead of fossil-fired plants in order to comply with the commitments to reduce CO_2 emissions.

KEY ISSUES

(1) For some NPP's stranded cost recovery is a pre-requisite to be competitive. One of the most important issue during the transition period to a liberalized market is the recognition of the stranded costs (and liabilities), basically the capital costs which were incurred by the existing utilities in the previous framework of cost-of-service regulation, as authorized by the public authorities, and which cannot be recovered from the market. This recognition is provided in the European Directive 96/92/CE dated 19 December 1996 and now each country of the European Union will have to set the exact amount to be passed on to all final customers.

However, for many NPP's even if stranded costs were not fully recovered, it would be more profitable for them to continue operation than to shut down because in this way at least a part of the capital costs would be recovered; shutting down would mean that none of these costs could be recovered.

Securitization of these stranded costs is a possibility contemplated by the affected utilities in order to provide financial stability to their future recovery. This has already been accomplished successfully in Spain with the sunk costs of the five NPP's under construction which were canceled some years ago by the Government and is also expected to be applied to a portion of the stranded costs.

For nuclear power stations, stranded costs and liabilities include also the funds required for the final disposal of radioactive waste and for the dismantling of the stations on completion of their service lifetime.

(2) Will the conditions which have led to the establishment of liberalized electricity markets stay?

Some think that the main factors driving the overwhelming trend to adopt deregulated market schemes have been (1) the existence of overcapacity, partially amortized, after many years of continued power plant construction intermingled with periods of low economic growth, (2) the current availability of abundant and relatively cheap natural gas and (3) the progress experienced in the development of combined-cycle plants which are now approaching efficiencies as high as 60%. A profound alteration of these factors - basically the eventual absorption of the overcapacity and a substantial increase in natural gas prices, coupled in all cases to the CO_2 issue- may lead to a completely different scenario in which there might be room for a diversified portfolio of electricity-producing technologies including nuclear.

(3) So far, nuclear power has not had the opportunity to capitalize on being emission free. The competitiveness of nuclear power plants will improve if they are able to monetize their carbon-free characteristic (either by getting premiums associated to that or by trading emission credits with other polluting industries).

(4) Achieving stabilization of the regulatory environment is essential. In the past, the rapid increase in the number of standards, rules and regulations applicable to the design, construction and operation of nuclear power plants was one of the main causes of the cost overruns that affected the plants being built at that time. The Three Mile Island accident contributed to that.

Achieving regulatory stabilization is an essential factor to start and complete successfully a new cycle of nuclear plant construction.

(5) Ageing is a problem and an opportunity. A nuclear plant, as any other industrial installation, requires a certain amount of on-going capital investment to maintain its full operational capacity and comply with new regulatory requirements. This investment tends to grow with age.

Once the initial capital cost has been fully depreciated after 20-25 years of operation and if the plant has been kept in good order, only moderate additional investment will be needed to extend the service life to 40 years and beyond. A reference figure is $ 33 million per year which is equivalent to an additional 0.47 ¢/kWh in operating cost. This can be the cheapest option when it comes to installing new capacity.

(6) There might be some financial barriers to the future deployment of nuclear power. As nuclear power is capital-intensive, a nuclear power plant requires a long period of time (25-30 years) to fully depreciate the initial capital cost. In a deregulated market, recovery of the investment is accomplished by selling the production, the kWh, which is by no means guaranteed unless long term contracts could be signed with either traders or final customers.

Raising the large amounts of money (say 2 billion dollars for each 1,000 MW plant) required to build new nuclear power plants under these conditions might be an important barrier to the massive redeployment of nuclear power.

(7) Finding the necessary manpower might be another barrier. Another barrier might be finding the necessary manpower, in appropriate numbers and with the high technical skills required, to support a large program of new constructions 10-15 years from now. Although a portion of today's nuclear industry will likely still be around, the question is whether or not it will be able to absorb and train in a timely manner the large amounts of new resources required. In the 1960's and 1970's the same challenge was successfully surmounted. Will it happen again?.

CONCLUSION

Nuclear power is no different from other products or technologies in that its long-term viability depends on its ability to be economically competitive on the market. The new sensitivity to global warming and the efforts being made by the nuclear industry to come up with a new generation of advanced reactors, standardized, certified by the regulatory authorities and, consequently, cheaper to build, should give nuclear power the opportunity to succeed on the market when the time comes for the decision on the large amounts of new capacity that will be required.

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He began his nuclear career in the late 1960's in the United States, as a nuclear start-up engineer with General Electric. During the 1970's he participated in the design and construction of Lemoniz Nuclear Power Plant in northern Spain, as Head of the Nuclear Department of the Spanish utility Iberduero (now merged into Iberdrola).
In the early 1980's he moved to UNESA, the association of the Spanish utilities where he is Director of the Nuclear Area, in charge of coordinating specific nuclear activities of the Spanish utilities.
He was a member of the Steering Committee chaired by Lord Marshall that set up WANO and also Chairman of the Steering Committee which organized the Paris Center. Vice-Chairman of the Paris Center for two consecutive terms, he is now Governor of WANO and Chairman of the Paris Center-Moscow Center Advisory Committee for the safety upgrading of Soviet-designed nuclear power plants.