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The economics of nuclear energy

In common with many of the issues surrounding nuclear energy, there is some truth in the popular claim that nuclear energy is "not economic", but this is far from being a universal truth. Overall, nuclear energy can be a competitive source of electricity and a realistic economic option for the future.

There are currently 362 nuclear power plants operating in OECD countries and virtually all of them compete economically within the markets in which they are situated. This is irrespective of these markets being regulated or liberalised.

Nuclear power plants are characterised by high capital costs; the incremental costs of operation are generally below the value of the electricity that the plants generate. There is also good evidence that these operational costs are being reduced. The most valuable actions being pursued and achieved by owners are increases in plant load factors, the uprating of plant capacities and the extension of plant lifetimes. For example, nuclear plants in the United States increased generation by more than 30% between 1990 and 2000 while no new plants were commissioned. Furthermore, again in the US, 10 nuclear power plants have recently received regulatory approval to extend their operating lives from 40 to 60 years; 16 applications for license renewal are under review and 27 more plant operators have expressed the intention to file a request for such renewal. All of these actions, which necessitate the investment of time, effort and knowledge, and sometimes physical investment, result in increased generation from the asset at costs close to operating costs – a very attractive business opportunity for all stakeholders.

When existing plants close, they generally do so for two reasons, one of which is economic non-viability, the second being political or social intervention. Economic non-viability usually arises because a non-recurring expenditure has to be made, the cost of which cannot be justified in commercial terms.

The choice of technology for new generating plant

Nuclear energy has not been the electricity generation technology of choice in most countries for two decades or more. There are social concerns about and political difficulties with nuclear technology that centre on the perceived safety risks, the disposal of radioactive waste and the risk of weapons proliferation. Moreover, some countries do not need to invest in any new electricity generating plants at present since consumer demand is being satisfactorily met by existing installations. But, notwithstanding these issues, what would be the economics of a new nuclear power plant?

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The most recent study published by the Nuclear Energy Agency (NEA), working jointly with the International Energy Agency (IEA), reports and analyses data provided by OECD member and non-member country governments regarding electricity generating plants to be commissioned in 2005. Levellised costs, discounting the lifetime cash flows using a rate of 5% per annum, showed that nuclear energy was the most attractive economic option by a significant margin in 5 countries out of the 18 from which comprehensive responses had been received. At a discount rate of 10% per annum, the nuclear option was never the most attractive.

Levellised cost and discount rate

The levellised cost methodology discounts the time series of expenditures and incomes to their present values in a specified base year by applying a discount rate. Applying a discount rate takes into account the time value of money, i.e. a sum earned or spent in the past or in the future does not have the same value as the same sum (in real terms) earned or spent today. The discount rate may be related to rates of return that could be earned on typical investments; it may be a rate required by public regulators incorporating allowance for financial risks and/or derived from national macro-economic analysis; or it may be related to other concepts of the trade-off between costs and benefits for present and future generations.

Source: NEA (1998), *Projected Costs of Generating Electricity: 1998 Update,* OECD, Paris [out of print].

The sensitivity of total costs to changes in the cost elements are very different. For combined-cycle gas-fired power plants, the technology of "choice" today, the cost of gas accounts for more than two-thirds of the total generation cost. Thus the outcome of a comparative analysis depends critically on the future price of gas over the lifetime of the plants. The IEA currently projects the future price of gas over the first quarter-century of this millennium as being below the level prevailing in 2000 and less than half that of 1980, in real terms. Certainly this reference projection reflects "conventional wisdom", but there is much scope for adopting an analysis based on a range of different scenarios.

On the other hand, nuclear energy costs are dominated by the capital investment. Other costs are relatively small, including nuclear plant decommissioning. Once built, a nuclear power plant offers stable electricity costs over a long period, provided that it operates successfully. The plant owner is exposed to financial risk from the construction, from regulatory uncertainty during both construction and operation and from market price uncertainty. The control of the owner's exposure to risks depends on the details of the commercial arrangements that support the nuclear power plant and it is difficult to generalise about them. However, the entities accepting these risks have to have the capacity to accommodate them and this points towards large and robust organisations or companies, including the generator. Small generators operating in a fully competitive market, probably in the private sector, may not have the appetite for investing in nuclear energy having seen the fate of all generators in the United Kingdom and in Sweden at the hands of harsh competition in the newly liberalised electricity markets.

One interesting challenge for the nuclear industry is the test of its historical approach of moving to larger and larger plants in order to achieve economies of scale. The most recent reactors commissioned in France have a 1 450 MWe capacity while the first commercial reactors built in Europe (at Calder Hall in the United Kingdom) had a 50 MWe capacity. However larger capacity means larger financial risk, and the place for this in the future is a topic of open debate. The alternative approach of reducing the size to better suit the needs of the electricity generation systems, to allow more use of factory-based manufacturing techniques and to benefit from series effects has yet to be tested.

Specific national assessments conducted recently by some OECD member countries show that nuclear energy is the most economic for electricity generation, viz. Finland, France and Japan. Other countries, such as the United Kingdom, have found otherwise.

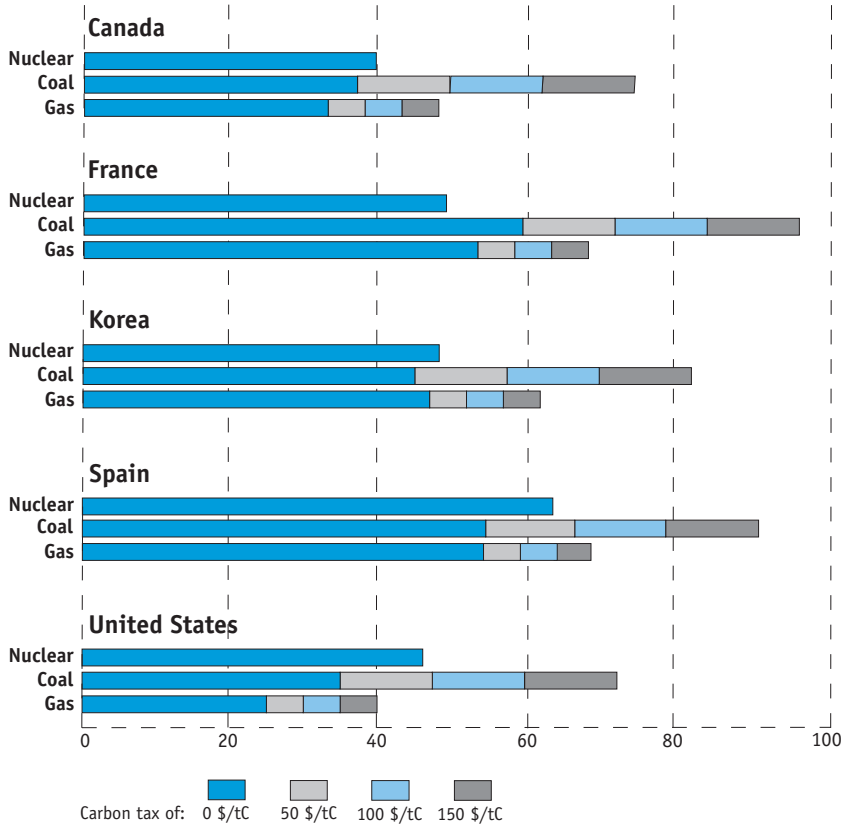
The economics of future nuclear power plants

At the heart of the future competitiveness of nuclear power plants are the capital costs, the investment needed at the outset. Obtaining definitive data on this has always been difficult but is increasingly so. Commercial confidentiality is an

issue and variations of project scope and conditions make comparisons difficult. However, it is clear that the suppliers of nuclear power plants have acted to improve and speed up construction management and to simplify plant design and manufacture. The benefits of a phased programme with ongoing replication are widely recognised. The products offered today, developed through a process of evolution, involve a reduced specific capital cost (US$ or €/kWe) relative to the plants built in the past. Perhaps a 25% reduction in the current guide price of US$2000/kWe installed capacity can be achieved by the evolutionary water reactors offered, for example, by Areva (EPR) or BNFL/Westinghouse (AP1000). The ultimate test is to build a plant selected by competitive tender and TVO in Finland is currently well-engaged in this process.

For the longer-term future, the industry looks to the outcome of today's investment in research and development for new, innovative products. Investment in R&D varies greatly between OECD member countries, from ¥288 billion per annum in Japan (c. US$ 2 billion) to very little in some European countries. The current R&D focus of some key countries, including OECD members and non-members, is the Generation IV International Forum (GIF) initiated by the United States and pursued jointly by Argentina, Brazil, Canada, France, Japan, the Republic of Korea, South Africa, Switzerland and the United Kingdom. The aim of the endeavour is to share the responsibility and cost of R&D focusing on nuclear energy systems selected for their innovative characteristics and promises for tomorrow. Tomorrow is being defined in the GIF context as plants ready for deployment by 2030. Some choices have been made against specific objectives, some of which relate to economics. The intention is to reduce the specific capital cost to around half the current level, reduce construction times and reduce financial risks to a level comparable to those for other generating technologies and fuels.

Levellised electricity generation costs (10% discount rate) and the effect of carbon tax



Regarding renewable energy sources for the future as an alternative to nuclear, all citizens of the world, especially those in Europe, would welcome a large, inexpensive, safe, environmentally benign energy source for the future. However, it is far from clear that renewable energy sources can meet these ideal goals. In terms of economics, non-hydro renewable energy sources are currently expensive and most of them are intermittent, therefore requiring additional investment in back-up plant. Interestingly, renewable energy sources share a high-capital intensity with nuclear energy and therefore also carry large financial risks. It would be unwise to close our eyes to any option for the future, including nuclear energy, until the aspirations of the proponents of renewable energy sources become a welcome reality.

Broadening the economic picture

Is this all the economics story? From the point of view of governments, it is not. Energy, and electricity in particular, are key ingredients of our healthy and prosperous lives that many developing countries are missing. Its production and use have impacts, positive and negative, which reach beyond economic markets. External costs are those which are not included within the price for a product paid by the customer and consequently are borne by society. These are assessed using life cycle cost analyses and impact pathway analyses, the most comprehensive study of which, for electricity generation, is the ExternE Project, sponsored by the European Commission. The study focuses on the environmental costs of electricity generation systems and broadly shows that the external costs of the nuclear electricity generation chain are of the order of 10% of the market price of electricity; a similar figure applies to renewable energy produced from wind. However, the external costs associated with the generation of electricity by the combustion of fossil fuels (gas or coal) range up to 100% of the electricity market price. Such a discrepancy implies a weakness in today's market arrangements that needs to be speedily addressed in order to direct investment towards a more sustainable development approach.

Other aspects of the technology choices for generating electricity will also be of considerable interest to governments. These include security of energy supply, balance of trade and employment – all of which have the potential to influence national choices for electricity generation. Probably, consideration of these would enhance the competitive position of nuclear energy, were they to be quantified as external costs and internalised within the price of electricity.

Concluding remarks

Economically, nuclear energy is broadly "within the market" today. The specific individual characteristics of OECD member countries influence whether it is an attractive economic choice for new investment in generating technology in local circumstances. Sometimes, non-economic considerations are at the fore in determining national policies.

In the future, the relative economics of nuclear energy will depend on its technical development, but even more so on the evolution of renewable energy technologies, the price of fossil fuels and the importance attributed to external costs, including those associated with the environment and global warming.

Inexpensive renewable energy sources and inexpensive fossil fuels over the next 50 years do not seem to be assured. In addition, the existence of external costs must not be overlooked by governments. From the economic perspective, nuclear energy is a realistic economic option for the future that cannot be ignored. ■

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