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Nuclear energy economics in a sustainable development perspective

In order to contribute effectively to sustainable development goals, a technology option must meet the test of economic efficiency to justify its use of scarce capital. However, in a sustainable development perspective, this test should be considered in a broad context, taking into account the need to preserve capital assets of all kinds: natural, man-made, human and social. Assessments of competitiveness in this context should be based upon comparisons of full costs to society of a product or a service.

At present, many of the costs associated with the supply of goods and services are not reflected in their market prices. In the power sector, for example, the production and use of electricity creates costs external to traditional accounting practices, such as damages to human health and the environment, that are not borne by producers or consumers. Those "external" costs are supported by society as a whole, now or in the future.

Economists are looking for ways of valuing these costs and incorporating them into prices, i.e. internalising the externalities. Within a sustainable development framework, getting the prices right so that market mechanisms can operate efficiently implies taking into account social and environmental costs for present and future generations. On that basis, the comparative assessment of alternative technologies will become an effective policy-making tool.

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Economic characteristics of nuclear energy

Nuclear energy has a number of unique economic characteristics that affect its attractiveness from a sustainable development perspective. Nuclear energy programmes imply long-term commitments from policy makers and investors, so financial risks and future liabilities arising from nuclear activities deserve careful consideration. Nuclear power plants are capital-intensive, but have low and stable marginal production costs. The nuclear industry sector requires a comprehensive infrastructure, including highly qualified manpower that contributes to increasing human capital assets. It uses limited amounts of natural resources and helps to provide security of supply.

The construction time of current nuclear units, around 5 years or more, and their expected technical lifetimes, up to 60 years or more, may raise some issues for private investors and power plant owners facing deregulated markets, but are consistent with the long-term perspective adopted by decision makers aiming at the implementation of sustainable development policies. It takes a long time, generally more than two decades, to amortise the capital invested in a nuclear power plant. The need to run the plant at a high rate of utilisation for many years before the investment is paid back raises financial risks associated not only with potential technical failures, but also with uncertainties about the stability of regulation and the growth of market demand.

Investment typically represents some 60% of the total generation cost of nuclear electricity. The capital cost of a 1 GWe nuclear unit is roughly

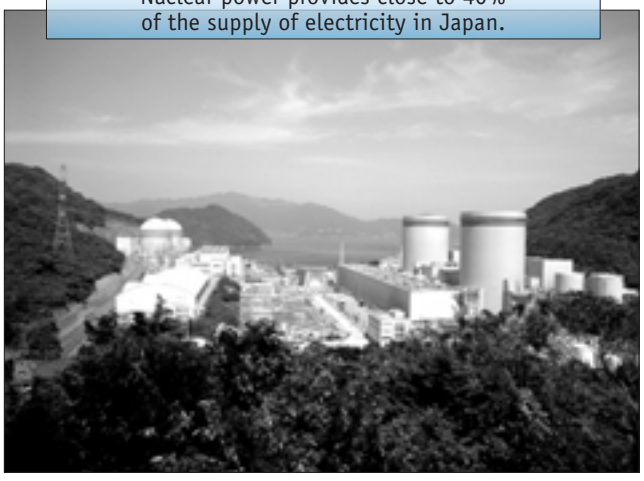
US$ 2 billion. Once built, on the other hand, nuclear plants have rather low fuel and operating costs, compensating for the need to amortise their capital investment. Since the cost of uranium represents only some 5% of the cost of electricity from nuclear plants, even a significant rise in the cost of uranium would have little impact on the total cost of nuclear-generated electricity.

The large size of uranium resources and their balanced geopolitical distribution worldwide ensure long-term security of supply. Uranium, and thorium, another potential nuclear fuel, are generally not useful for other significant purposes. The recovery of their energy content decreases the demand for other, more versatile energy resources, thereby contributing further to sustainable development. Because of the high energy density of nuclear fuel, nuclear energy requires a very small flow of energy materials, in mass or volume terms, and makes small demands on the natural resource base and the environment. This also means that nuclear fuel can be stockpiled for several years at reasonable costs, decreasing concerns about energy security in the short term.

Economically recoverable uranium resources are large enough to cover demand for many decades at current rates of consumption. Moreover, if demand was to increase, higher prices could bring still more resources on stream. Advanced fuel cycles, in particular those taking advantage of fissile material recycling, could allow the resource base to be further extended by a factor of sixty or more, ensuring a nuclear fuel supply for centuries to come, even if the use of nuclear energy is greatly expanded.

The nuclear energy sector requires R&D and education infrastructures as well as comprehensive legal and institutional frameworks. Requirements for a high level of technical and managerial know-how create demand for highly qualified manpower, bringing macroeconomic and social benefits. The spin-off benefits of nuclear energy activities are widespread and enhance its contribution to the economic and social goals of sustainable development. Nuclear power plants and fuel cycle facilities contribute to the man-made asset passed on to future generations, while experience in operating the nuclear fuel cycle adds to the human and intellectual capital base.

Nuclear power provides close to 40% of the supply of electricity in Japan.



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Future financial liabilities arise from the need to cover the costs of decommissioning nuclear facilities and disposing of long-lived radioactive waste. Those liabilities were recognised at an early stage. Measures taken by the industry and governments to establish and guarantee adequate funds for these liabilities are consistent with the objective of not passing undue burdens on to future generations. The high energy density of nuclear fuel and the large amount of electricity that it produces allow for adequate funds to be generated from a small surcharge on the price of electricity to consumers.

Competitiveness of nuclear power

Existing nuclear power stations tend to have low operating and fuelling costs as noted above. This makes them highly competitive on a marginal cost basis. Recent experience, in the United States, the United Kingdom, Sweden and Finland for example, demonstrates that nuclear power plants perform well in deregulated markets. Existing nuclear power plants that were built at low original costs, or where the initial costs have been largely amortised, can be very competitive and profitable. They are expected to continue operating well beyond the time required to amortise the investments that were made in them.

Most existing nuclear power plants have improved their technical performance significantly over the past decade. The availability factors of nuclear units exceed 80% in most OECD countries. Simultaneously, operation and maintenance costs have been reduced, taking advantage of feedback from experience, as demonstrated by the figures published by US and German operators for example. This has led to a drastic improvement of the overall economic indicators of nuclear power plants.

The possibility of improving the technical performance of existing nuclear power plants, as well as increasing their power capacities and

Nuclear electricity generating costs

Country	Discount rate %	Investment %	O&M %	Fuel %	Total cost US cents/kWh
Canada	5	67	24	9	2.5
	10	79	15	6	4.0
Finland	5	59	21	20	3.7
	10	73	14	13	5.6
France	5	54	21	25	3.2
	10	70	14	16	4.9
Japan	5	43	29	27	5.7
	10	60	21	19	8.0
Korea (Republic of)	5	55	31	14	3.1
	10	71	20	9	4.8
Spain	5	54	20	26	4.1
	10	70	13	17	6.4
Turkey	5	61	26	14	3.3
	10	75	17	9	5.2
United States	5	55	27	19	3.3
	10	68	19	13	4.6

extending their lifetimes, offers prospects for enhanced competitiveness in the coming years and decades. Many countries, even those with moratoria on further construction, have increased their installed nuclear capacity through upgrading existing plants. Lifetime extension is cost-effective in most cases, even if some upgrading may be required to meet current safety standards.

For new power plants, the data in *Projected Costs of Generating Electricity* (OECD/NEA, 1998) show that nuclear power is seldom the cheapest option. In a deregulated market context, meaning high discount rates, and with the present prices of hydrocarbons, natural gas is a very strong competitor. However, these studies do not take account of the recent increases in the price of oil and natural gas. In the case of North America, natural gas prices have gone up by a factor of three or four in the last two years. While prices may not hold at current levels, it now looks as if they will be maintained at a higher level than was anticipated in the late 1990s.

In the longer term, nuclear power plants will have to compete not only with state-of-the-art, fossil-fuelled plants but also with renewable energy technologies that are expected to improve their performance and reduce their prices through scientific and technical progress and commercial development. In this context, there is a need in most cases to ensure that the capital cost is reduced, along with the planning and construction times. Some reactor designers and manufacturers plan to reduce capital costs by 30 to 40% for designs that are available now or will be in the next few years, and to reduce construction times to five years or less. Planning would be helped by a standardised and predictable approach to regulation.

The relative competitiveness of alternative options for electricity generation depends strongly on the discount rate used to calculate cost estimates. With a 5% discount rate, nuclear power plants that would be built today would compete favourably with alternatives in many countries, but with a 10% discount rate gas-fired power plants would be the winner nearly everywhere. High discount rates, in line with the economic objectives of private investors in deregulated markets, enhance the competitiveness of technologies that are not capital-intensive, such as gas turbines. On the other hand, low discount rates, which reflect a preference for a future consistent with sustainable development goals, favour capital-intensive technologies such as nuclear power and renewable energy sources.

External costs

The health and environmental external costs of electricity are limited by norms, standards and regulations aiming at reducing residual emissions and burdens from fuel cycles for electricity generation. In the case of nuclear energy, the industry is

operating under stringent safety regulations, tight limits on atmospheric emissions and liquid effluents, and commitments to contain radioactive waste. The industry is also supporting the corresponding costs of these responsibilities, thereby internalising the expense.

A significant proportion of nuclear energy cost is due to safety features designed to prevent nuclear workers and the public from receiving radiation doses in excess of permitted levels, in conformity with stringent environmental and safety regulations. The internalisation of external costs extends to long-lived radioactive waste disposal and plant decommissioning through the establishment of funds to cover future financial liabilities. The liability in the event of major accidents is also internalised, although in most cases the total liability of the industry is effectively capped, and governments do carry the residual risk that constitutes an externality. Some countries have unlimited liability, but since the ability of the industry to pay is limited, governments still end up with the residual risk. Most other industries are only beginning to think about liability regimes for long-term impacts.

Comparative studies carried out recently, such as the ExternE project implemented under the auspices of the European Commission, show that alternative options for electricity generation, including fossil and renewable sources, have not fully internalised their respective external costs. There are no generic conclusions since impacts of energy fuel cycles are often site-specific, but generally speaking, nuclear energy fuel cycles have lower external costs than alternative options, even when the possibility of accidental releases is considered.

The adoption of environmental protection regulations has led to the implementation of cleaner technologies. State-of-the-art, fossil-fuelled power plants include pollution abatement devices which, at a cost, reduce atmospheric emissions to levels thought to be harmless. The notable exception is the risk of global climate change resulting from carbon dioxide and other greenhouse gas emissions.

Although it is not possible to assess with a reasonable degree of certainty the value of global climate change damages in the long term, it is a major risk that should be avoided within a sustainable development framework. Passing on to future generations the burdens associated with climate change that arise from activities that benefit the current generation is certainly not consistent with sustainable development objectives.

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Not passing on burdens to future generations is an essential element of sustainable development.

Conclusion

Nuclear power plants in operation, including those in deregulated markets, are generally competitive since their marginal costs are low as compared with alternatives. Furthermore, experience shows a continued trend towards improving operating performance of existing reactors as well as economic performance.

The research, development and design efforts being made by reactor designers could lead to significant reductions in capital costs and construction times for the next generation of reactors. These reductions will be essential in order to lower financial risks associated with nuclear energy and to attract investors.

The economic goals of sustainable development require that the full costs of a given technology be factored into the price of its product. The nuclear energy sector has gone a long way in this direction and its present costs reflect a fairly complete integration of environmental and social burdens associated with nuclear electricity generation. Therefore, the internalisation of external costs for all technologies and energy sources would likely enhance the competitiveness of nuclear energy. However, this is likely to take some time. Meanwhile, the nuclear industry must be active in reducing its costs in a competitive environment, while ensuring that high standards are maintained with respect to health, safety and environmental impacts. It must convince investors and the public that nuclear energy is a good investment for the future in the broadest economic, environmental and social terms. ■