The Future of Nuclear Power

AN INTERDISCIPLINARY MIT STUDY

Executive Summary

STUDY CONTEXT

Over the next 50 years, unless patterns change dramatically, energy production and use will contribute to global warming through large-scale greenhouse gas emissions — hundreds of billions of tonnes of carbon in the form of carbon dioxide. Nuclear power could be one option for reducing carbon emissions. At present, however, this is unlikely: nuclear power faces stagnation and decline.

This study analyzes what would be required to retain nuclear power as a significant option for reducing greenhouse gas emissions and meeting growing needs for electricity supply. Our analysis is guided by a global growth scenario that would expand current worldwide nuclear generating capacity almost threefold, to 1000 billion watts, by the year 2050. Such a deployment would avoid 1.8 billion tonnes of carbon emissions annually from coal plants, about 25% of the increment in carbon emissions otherwise expected in a business-as-usual scenario. This study also recommends changes in government policy and industrial practice needed in the relatively near term to retain an option for such an outcome.

We did not analyze other options for reducing carbon emissions — renewable energy sources, carbon sequestration, and increased energy efficiency — and therefore reach no conclusions about priorities among these efforts and nuclear power. In our judgment, it would be a mistake to exclude any of these four options at this time.

STUDY FINDINGS

For a large expansion of nuclear power to succeed, four critical problems must be overcome:

- Cost. In deregulated markets, nuclear power is not now cost competitive with coal and natural gas. However, plausible reductions by industry in capital cost, operation and maintenance costs, and construction time could reduce the gap. Carbon emission credits, if enacted by government, can give nuclear power a cost advantage.
- Safety. Modern reactor designs can achieve a very low risk of serious accidents, but "best practices" in construction and operation are essential. We know little about the safety of the overall fuel cycle, beyond reactor operation.
- Waste. Geological disposal is technically feasible but execution is yet to be demonstrated or certain. A convincing case has not been made that the long-term waste management benefits of advanced, closed fuel cycles involving reprocessing of spent fuel are outweighed by the short-term risks and costs. Improvement in the open, once through fuel cycle may offer waste management benefits as large as those claimed for the more expensive closed fuel cycles.
- Proliferation. The current international safeguards regime is inadequate to meet the security challenges of the expanded nuclear deployment contemplated in the global growth scenario. The reprocessing system now used in Europe, Japan, and Russia that involves separation and recycling of plutonium presents unwarranted proliferation risks.

We conclude that, over at least the next 50 years, the best choice to meet these challenges is the open, once-through fuel cycle. We judge that there are adequate uranium resources available at reasonable cost to support this choice under a global growth scenario.

Public acceptance will also be critical to expansion of nuclear power. Our survey results show that the public does not yet see nuclear power as a way to address global warming, suggesting that further public education may be necessary.

SELECTED RECOMMENDATIONS

- We support the Department of Energy (DOE) 2010 initiative to reduce costs through new design certification, site banking, and combined construction and operation licenses.
- The government should also share "first mover" costs for a limited number of power plants that represent safety-enhancing evolutionary reactor design. We propose a production tax credit for up to $200/kWe of the plant's construction cost. This mechanism creates a strong incentive to complete and operate the plant and the mechanism is extendable to other carbon-free technologies. The government actions we recommend aim to challenge the industry to demonstrate the cost reductions claimed for new reactor construction, with industry assuming the risks and benefits beyond first- mover costs.
- Federal or state portfolio standards should include incremental nuclear power capacity as a carbon free source.
- The DOE should broaden its long-term waste R&D program, to include improved engineered barriers, investigation of alternative geological environments, and deep bore hole disposal. A system of central facilities to store spent fuel for many decades prior to geologic disposal should be an integral part of the waste management strategy. The U.S. should encourage greater harmonization of international standards and regulations for waste transportation, storage, and disposal.
- The International Atomic Energy Agency should have authority to inspect all suspect facilities (implement the Additional Protocol) and should develop a worldwide system for materials protection, control, and accountability that goes beyond accounting, reporting, and periodic inspections. The U.S. should monitor and influence developments in a broad range of enrichment technologies.
- The DOE R&D program should be realigned to focus on the open, once-through fuel cycle. It should also conduct an international uranium resource assessment; establish a large *nuclear system analysis, modeling, and simulation project*, including collection of engineering data, to assess alternative nuclear fuel cycle deployments relative to the four critical challenges; and halt development and demonstration of advanced fuel cycles or reactors until the results of the nuclear system analysis project are available.