by Sharon Squassoni

Hanging Questions

A nuclear renaissance would require significant changes by both governments and multinational agencies as well as aggressive financial support.

After several decades of disappointing growth, nuclear energy seems poised for a comeback. Talk of a "nuclear renaissance" includes perhaps a doubling or tripling of nuclear capacity by 2050, spreading nuclear power to new markets in the Middle East and Southeast Asia, and developing new kinds of reactors and fuel-reprocessing techniques.

But the reality of nuclear energy's future is more complicated. Projections for growth assume that government support will compensate for nuclear power's market liabilities and that perennial issues such as waste, safety, and proliferation will not be serious hurdles. However, without major changes in government policies and aggressive financial support, nuclear power is actually likely to account for a declining percentage of global electricity generation. For example, the International Energy Agency's World Energy Outlook 2007 projects that without policy changes, nuclear power's share of worldwide electricity generation will drop from 15% in 2007 to 9% in 2030.

Given the seriousness of these uncertainties, a sound policy on nuclear energy should be based not on hope but on solid answers to six questions.

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Can Nuclear Power Enhance Energy Security?

Rising prices of oil and natural gas have had a cascading effect on countries' concerns about energy security. Price disputes have resulted in temporary cutoffs of natural gas supplies in Europe in the past few years. But most countries will not be able to reduce their dependence on foreign oil by building nuclear power plants. Nuclear power—because it currently only provides electricity—is inherently limited in its ability to reduce this dependence. For example, 40% of the energy consumed in the US comes from oil, yet oil produces only 1.6% of electricity. And even though France and Japan rely heavily on nuclear energy, they have been unable to reduce their dependence on foreign oil because of oil's importance for transportation and industry.

Oil accounts for about 7% of power generation globally, a share that is expected to decline to 3% by

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2030. Only in the Middle East, where countries rely on oil for about 30% of their electricity generation, could substitution of nuclear power for oil make a significant difference. Until transportation switches to electricity as its fuel, nuclear energy largely will not displace oil.

The situation is different for natural gas. Although natural gas also has industrial and heating uses, it produces about one-fifth of electricity worldwide. Natural gas is attractive as a way to produce electricity because gas-fired generating plants are very efficient at converting primary energy into electricity and also cheap to build, compared with coal- and nuclear-fired plants. Nuclear energy could displace natural gas for electricity production and improve some countries' stability of energy supply.

Ultimately, however, countries may be trading one form of energy dependence for another. Given the structure of the nuclear industry and uranium resource distribution, most countries will need to import fuel, technology, and reactor components, as well as fuel services. This means that few countries can expect more than interdependence, even when it comes to nuclear power.

Can Nuclear Power Contribute to Controlling Climate Change?

Nuclear power is not a near-term solution to the challenge of climate change. The need to immediately and dramatically reduce carbon emissions calls for approaches that can be implemented more quickly than building nuclear reactors. It also calls for actions that span all energy applications, not just electricity. Improved efficiency in residential and commercial buildings, industry, and transport is the first choice among all options in virtually all analyses of the problem. Nuclear energy will remain an option among efforts to control climate change, but given the maximum rate at which new reactors can be built, much new construction will simply offset the retirement of nuclear reactors built decades ago.

For nuclear energy to make a larger difference in meeting the challenge of climate change, the industry would need to add capacity exceeding replacement levels. According to a 2007 study by the Keystone Center, this would require "the industry to return immediately to the most rapid period of growth experienced in the past (1981–1990) and sustain this rate of growth for 50 years." This would mean completing twenty-one to twenty-five new, large (1,000MW electric) plants each year through 2050.

Yet the global nuclear construction industry has shrunk. In the past twenty years, there have been fewer than ten new reactor construction starts worldwide in any given year. Today there are already bottlenecks in the global supply chain, including ultra-heavy forgings, large manufactured components, engineering, craft labour, and skilled construction labour. All these constraints have been exacerbated by the lack of recent experience in building nuclear plants and by aging labour forces.

Will New Nuclear Power Plants Be Economically Competitive?

The economic competitiveness of nuclear power is a subject of much debate. Nuclear power plants are expensive to build but relatively inexpensive to operate, because their fuel costs are low compared with alternatives. For example, the price of natural gas accounts for 85% of the variable cost of a kilowatt-hour, whereas nuclear fuel accounts for 27%. This means that as the cost of fossil fuels rise, either due to short supply or because carbon dioxide emissions may in the future be regulated, nuclear power will become relatively more competitive.

A big uncertainty is the cost of constructing new nuclear power plants. As a general rule, about two-thirds of a nuclear reactor's cost stems from construction. Factors affecting this cost of construction include the creditworthiness of the companies involved in building the reactors, the cost of capital (especially debt) over the next decade, the risk of cost escalation due to construction delays and overruns, less need for additional generating capacity in a slowing economy, and the competitive advantage of both traditional and emerging power generation technologies.

Because data from the past unfortunately provide little help in assessing future costs, the real costs of new nuclear power plants may not be known for years. In fact, Moody's stated in a special October 2007 report that "the ultimate costs associated with building new nuclear generation do not exist today—and that the current cost estimates represent best estimates, which are subject to change."

The current economic crisis could make financing nuclear power plants particularly difficult. Financing

costs account for between 25 and 80% of the total cost of construction because nuclear power plants take much longer to build than alternatives (for example, wind plants require eighteen months to build, combined-cycle gas turbines need thirty-six months, and nuclear power plants take at least sixty months). A global tightening of risk management standards in the wake of the current economic crisis could imperil the nuclear industry in particular, because a reactor entails such a large investment (between $5 billion and $10 billion per plant) relative to the typical financial resources of electric utilities.

Can Safety Be Assured?

Concerns about the safety of nuclear power plants have played a major role in nuclear power's stagnation over the past two decades. Newer designs are much simpler and have built-in passive safety measures. Yet a big expansion of nuclear power could lead to new safety concerns as new suppliers from South Korea, China, and India could enter the field to meet expanded demand.

In addition, countries that are new to nuclear power must not only implement a complex set of regulations and laws but also foster the development of resilient safety and security cultures. This could be quite challenging for some developing countries.

Finally, in states with existing power plants, the extension of reactor operations beyond their initial lives of thirty or forty years to sixty or even eighty years could potentially result in new safety concerns if construction materials age in unanticipated ways.

Is an Acceptable Solution to Nuclear Waste at Hand?

Nuclear reactors unavoidably generate radioactive spent fuel as waste. Some states will opt to store spent nuclear fuel indefinitely. Others may seek to recycle it, using a technique known as reprocessing, which reduces the volume of waste that needs to be stored but produces separated plutonium, a nuclear weapons fuel. More than fifty years since the first reactor produced electricity, no country has yet opened a permanent site for nuclear waste-known as a geologic repository.

Whether nations are storing spent fuel or recycled waste, adequate physical protection and security against terrorist access are both essential. Even in fuel-leasing schemes, in which spent fuel would be shipped back to the original supplier, new nuclear states will still require safe and secure interim storage for fuel as it cools. A key question for the future of nuclear energy is how many countries will choose to reprocess their fuel. Some states, such as South Korea, are interested in reprocessing to reduce the volume of their spent fuel. Japan has been reprocessing its spent fuel to both reduce the volume and use the plutonium for fuel as part of an effort to strengthen its energy security. Although there is much evidence that the use of mixed fuel (plutonium and uranium) in reactors is uneconomical, some countries may use it anyway. This would vastly increase the quantities of nuclear weapons material available around the world.

Can Proliferation Risks Be Adequately Controlled?

The International Atomic Energy Agency (IAEA) has cautioned that states just beginning to embark on the path toward nuclear energy can expect at least fifteen years to elapse before their first plant begins operation. They will need this time to develop the necessary physical and intellectual infrastructures to run nuclear power plants safely and securely.

Many of the countries interested in nuclear power anticipate sizable growth in electricity demand. Others may simply be jumping on the nuclear bandwagon, either to make a national statement about capabilities or to take advantage of what they may perceive as incentives from advanced nuclear states, particularly France, Russia, and the US.

In 2008, the International Security Advisory Board of the US Department of State concluded that "the rise in nuclear power worldwide, and particularly within Third World countries, inevitably increases the risks of proliferation." Only nuclear energy, among all energy sources, requires international inspections to ensure that material, equipment, facilities, and expertise are not misused for weapons purposes. For those countries that do not already have nuclear programs, developing the scientific, engineering, and technical base required for nuclear power would in itself heighten their proliferation potential. Political instability in many cases is a more prominent concern than weapons intentions.

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7 Steps

Sharon Squassoni of the Carnegie Endowment for International Peace suggests that some of the risks related to a rapid expansion of nuclear power could be minimized by adopting the following measures:

❶ Compare All Energy Options, Including Efficiency

Because moving world energy use away from dependence on carbon-based fossil fuels will require enormous investments, it will be essential to carefully weigh the costs and benefits of all possible solutions, including drastically improved efficiency. The only sensible approach to climate change is to prioritize investment in the lowest carbon energy options with the biggest impact that can be deployed immediately. These three criteria should be applied to assessing where nuclear power fits in among states' possible energy options. The IAEA and the International Energy Agency could collaborate on such an approach. Alternatively, a new global energy agency might be organized to perform this task, among others, if needed.

❷ Take the Glamour Out of Nuclear Cooperation

Nuclear energy is often regarded by countries as a symbol of national prowess rather than simply as a way to produce electricity. Because nations have an inalienable right to pursue nuclear energy for peaceful purposes, part of the challenge in levelling the energy playing field will be addressing the allure of nuclear power.

In part, the glamour of nuclear power is enhanced by the perceived prestige of nuclear cooperation agreements. Some might argue that framework agreements provide the prestige that some states seek, even if little nuclear trade results. However, this approach is not sustainable over time. A more promising path would be to subsume discussions about nuclear cooperation under the broader rubric of energy cooperation, rather than pursuing them as technology-specific diplomatic initiatives.

❸ Adopt the Model Additional Protocol as a Requirement

The IAEA's Model Additional Protocol, which contains measures to strengthen the international system of inspections on nuclear material and facilities, was approved in 1997. However, because the protocol's adoption is not mandatory, around 100 states do not yet have it in force. Its measures—which include increased access for inspectors, a wider array of information about a state's entire fuel-cycle, provisions for short-notice inspections, and new monitoring techniques—are essential to enhance the IAEA's ability to detect undeclared nuclear activities.

The Model Additional Protocol needs to become the new benchmark for nuclear supply within the Nuclear Suppliers Group (NSG). All countries should incorporate a requirement for an additional protocol into their nuclear cooperation agreements as well as in vendor contracts.

❹ Supply Nuclear Reactors and Their Components Responsibly

The nuclear industry understands its own interdependence, particularly in the area of nuclear safety. The common refrain of "a nuclear accident

anywhere affects everyone everywhere" can be extended to nuclear security and to proliferation. Yet in an expanded nuclear world, there will be tremendous commercial pressures to supply nuclear reactors and their components to states that may not yet have all their regulatory, safety, and security infrastructures in place. To mitigate risk in such situations, vendors will need to agree on minimum requirements for the sale of nuclear reactors and components and include these requirements as standard clauses in contracts. It will be important to reach vendors outside the Nuclear Suppliers Group, particularly in India and Pakistan.

❺ Increase Transparency in Cooperation and Tighten Restrictions on Sensitive Technologies

Although US agreements are a matter of public record because of the requirement for congressional approval, this is not the case in other countries. Sharing the texts of cooperation agreements could help promote the standardization of nonproliferation requirements, including restrictions on sensitive technologies.

The NSG needs to make progress on tightening restrictions on sensitive technologies—that is, uranium enrichment, spent-fuel reprocessing, and heavy water production.

❻ Give Priority to Small, Proliferation — Resistant Reactor Designs

New emphasis and funding should be devoted to commercializing small, proliferation-resistant reactor designs that incorporate passive safety features. Although Russian floating reactors have been touted as proliferation resistant because they can be removed from a country once their operational lives have ended, their potential vulnerabilities with respect to security and protection against terrorist attacks need to be assessed more carefully.

And other possible designs—like the Pebble Bed Modular Reactor, under development by South Africa—should be internationally vetted against safety and safeguards standards. The Global Nuclear Energy Partnership could play a key role here, as the international forum known as Generation IV has in the technical development of the next generation of reactors. The partnership should focus more directly on helping commercialize the kinds of reactors that new nuclear states could deploy most profitably.

❼ Phase Out National Enrichment Capabilities Under a Fissile Material Production Cutoff Treaty

One of the most difficult aspects of restricting access to sensitive nuclear technologies like enrichment and reprocessing is the element of national prestige that is often attached to these high-profile projects. One way of divorcing the element of national pride from sensitive nuclear technologies is to ultimately "denationalize" these technologies. Existing plants would need to be converted to multinational ownership and, perhaps, operation. Such an approach would face heavy resistance, but it could be broached within the context of a fissile material production cutoff treaty (FMCT).

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An FMCT treaty could ban not just the production of fissile material for weapons, but could require all — existing and future — enrichment plants to be multinational. In addition to deflecting the element of national prestige, multinational enrichment facilities would raise the probability of detecting clandestine enrichment and hence substantially lower the risk of a national breakout from FMCT restrictions. Some countries, including the US, might need to alter laws or regulations regarding foreign ownership of these sensitive technologies or plants.