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Title:	Report of a Workshop on Nuclear Power Growth and Nonproliferation held at the Woodrow Wilson International Center for Scholars, Washington, DC, April 21, 2010
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Report of a Workshop on Nuclear Power Growth and Nonproliferation held at the Woodrow Wilson International Center for Scholars, Washington, DC, April 21, 2010

It is widely believed that an expansion of nuclear power would have positive energy, economic and environmental benefits for the world. However, there are concerns about the economic competitiveness, safety and proliferation and terrorism risks of nuclear power. The prospects for a dramatic growth in nuclear power will depend on the ability of governments and industry to address these concerns, including the effectiveness of, and the resources devoted to, plans to develop and implement technologies and approaches that strengthen nonproliferation, nuclear materials accountability and nuclear security.

In his Prague speech on April 5, 2009, President Obama stated: "we should build a new framework for civil nuclear cooperation, including an international fuel bank, so that countries can access peaceful power without increasing the risks of proliferation. That must be the right of every nation that renounces nuclear weapons, especially developing countries embarking on peaceful programs. And no approach will succeed if it's based on the denial of rights to nations that play by the rules. We must harness the power of nuclear energy on behalf of our efforts to combat climate change, and to advance peace opportunity for all people."

How can the President's vision, which will rekindle a vigorous public debate over the future of nuclear power and its relation to proliferation, be realized? What critical issues will frame the reemerging debate? What policies must be put into place to address these issues? Will US

policy be marked more by continuity or change? To address these and other questions, the Los Alamos National Laboratory in cooperation with the Woodrow Wilson International Center for Scholars hosted a workshop on the future of nuclear power and nonproliferation on April 21, 2010. (Final agenda attached.)

Summary

The workshop addressed the future of nuclear power and nonproliferation in light of global nuclear energy developments, changing US policy and growing concerns about nuclear proliferation and terrorism.

The discussion reflected wide agreement on the need for nuclear power, the necessity of mitigating any proliferation and terrorism risks and support for international cooperation on solutions. There were considerable differences on the nature and extent of the risks of differing fuel cycle choices.

There was some skepticism about the prospects for a global nuclear energy renaissance, but there was a recognition that nuclear power would expand somewhat in the decades ahead with some states expanding capacity dramatically (e.g., China) and at least a few new states developing nuclear power programs. It was also argued by some participants that under the right conditions, a genuine renaissance could occur some decades from now.

The prospects for a dramatic growth in nuclear power will depend on the ability of governments and industry to address these concerns, including the effectiveness of, and the

resources devoted to, plans to develop and implement technologies and approaches that strengthen nonproliferation, nuclear materials accountability and nuclear security.

Several participants noted that the United States will not be able to continue to lead global nonproliferation efforts and to shape the growth of nuclear power as well as the global environment and energy debates without a robust U.S. nuclear energy program.

Some participants argued that fully integrating nuclear energy growth and nonproliferation, proliferation resistance and physical protection objectives was possible. The growing consensus on these objectives and the growing concern about the potential impact of further proliferation on the industry was one reason for optimism.

The Blue Ribbon commission led by Scowcroft and Hamilton was seen as going far beyond the need to find an alternative to Yucca Mountain, and the preeminent forum in the next years to address the back end of the fuel cycle and other issues. Some argued that addressing these issues is the critical missing element, or the final piece of the puzzle to ensure the benefits of nuclear power and to promote nonproliferation. In this context, many argued that R&D on closed as well as open fuel cycle options in order to ensure a suite of long-term options was essential.

Nuclear power issues and the prospects for a nuclear renaissance

As a result of increasing energy demand, growing concerns over energy security, environmental initiatives aimed at reducing greenhouse gas emissions and other emerging

issues, nuclear energy is receiving growing interest and scrutiny in the coming decades. In the United States, President Obama has called for "a new generation of safe, clean nuclear power plants" and increased the loan guarantees for new nuclear plants.[1] In other parts of the world, nuclear power is being pursued even more aggressively and there is a sense that the utilization of nuclear energy to meet power needs will grow, perhaps dramatically, resulting in a "renaissance" of nuclear energy.

It is widely believed that the projected expansion of nuclear power would have positive energy, economic and environmental benefits for the world. However, there are concerns about its economic competitiveness (and in the United States at least, the economic viability of new nuclear plants), safety, proliferation and terrorism risks, etc. Public acceptance within the United States and elsewhere is largely tied to these and other issues and remains a key concern. For this and other reasons, it was widely recognized by participants that there may not be a fully-realized nuclear renaissance. In this context, many participants argued that any significant growth in nuclear power in the United States and globally will depend to greater or lesser extent on how the following issues are addressed.

Economics

It was widely held that unless the economics are favorable, there will be no revival of nuclear energy in the United States and long-term limits on growth in the rest of the world. Many participants noted that energy forecasts and nuclear cost estimates were both notoriously inaccurate, making it difficult to reach definitive economic assessments of nuclear power

[1]The US Congress passed the Energy Policy Act of 2005 (Public Law 109-58) which includes a 1.8 cent/kWh production tax credit for up to 6,000 MW of new nuclear facilities.

growth. Much will be determined by the price of fossil fuels as well as by local and national factors, i.e., state-specific, economic and regulatory factors. Several participants noted that nuclear will be competing primarily with coal and natural gas to produce base-load electricity. Loan guarantees, tax credits and other incentives could be useful to make nuclear more attractive economically. A number of participants suggested that some type of carbon tax or fee, including a cap and trade mechanism would increase the competitiveness of nuclear power and be beneficial for its growth. One participant argued that there will be no nuclear renaissance without a price on carbon. The high capital costs and long lead times, coupled with the likelihood of higher interest rates were put forward as negatives. The need for expanded human and industrial capacity to support nuclear power growth was also seen as a critical problem with negative cost implications. However, some stated that advances in design, construction and materials hold the promise of future reductions in capital costs and that licensing reform can address the time lines for reactor construction times, which has been a real problem in the United States.

Safety

Safety was not seen as critical an issue as cost. The safety of current nuclear power reactors has been well demonstrated, and the prospects for future improvements are significant, public perceptions of the safety of nuclear power to some extent remain colored by Three Mile Island and, more importantly, Chernobyl. The impact of these accidents has been diminishing, and it is important to note that a UN report concluded that the health impacts from the Chernobyl accident were not as severe as originally feared.[2] Nonetheless, any other

[2] "Chernobyl's Legacy: Health, Environmental and Socio-Economic Impacts," UN Chernobyl Forum.

significant accident could sharply limit if not eliminate prospects for future nuclear power in the United States and around the world.

Environmental Impact

One of the critical factors in the prospects for nuclear power growth will be its environmental impact. In contrast to past perceptions, it was widely recognized that today nuclear power appears to be an environmentally sound long-term energy source in comparison to oil, coal or natural gas. It increasingly appears to be an important pathway to addressing the risks of climate change. Some participants argued that the level of growth needed to make a significant dent in greenhouse gas emissions was daunting but potentially achievable if the global industry can ramp up its human and industrial capabilities. On the other hand, some recognized that if nuclear was not a growing part of the energy mix around the globe, the prospects of reducing the risks of climate change would be limited at best.

Back-end/waste management

The back end issues, including waste management and the possibility of closing the fuel cycle are highly contentious. Waste storage and transport are clearly negative in public perceptions of nuclear energy. It is a political problem that could limit the expansion of nuclear power. One participant noted that the waste management problem was not technological, but political. Another participant noted that waste did not pose a crisis, which meant a lack of urgency for decision makers to arrive at a solution.

In part at least in response to concerns about waste, some advocated a closed fuel cycle as the way to meet waste management goals and believe it will be economically viable in the future. Others raised objections to closing the fuel cycle on economic, proliferation and other grounds. While spent fuel reprocessing may be one possible long-term strategy to meet this requirement, many participants argued that centralized interim storage, perhaps for decades, may be more economically and politically viable. One participant suggested that deep bore hole disposal at reactor sites in the United States could be a viable solution. Many participants argued that R&D on closed as well as open fuel cycle options in order to ensure a suite of long-term options was essential.

Proliferation and terrorism risks

The perception that the growth of nuclear power will inevitably result in increased proliferation risks has often been overstated in the past—notably the charge that every reactor is a "bomb factory."[3] There is an undoubted connection between the civil and military atom and the risks of the nuclear enterprise are real.

One participant noted that nuclear power growth does not automatically lead to greater risks of proliferation and should not have an impact on security risks in the near term. Most of the growth will occur in states that already possess nuclear power programs and sensitive nuclear facilities (and in some cases, nuclear weapons), including China, India, the United States, Japan and Europe. Moreover, it was recognized that the chosen path for proliferators to date has largely been dedicated weapon programs rather than diversions from or other misuse of peaceful programs. In this context, one participant argued that a strategy to misuse civil

[3] See, e.g., Edward J. Markey, *Nuclear Peril: The politics of Proliferation* (Cambridge, MA: Ballinger, 1982).

nuclear facilities could be difficult to sustain and less attractive than dedicated programs because the development of sensitive facilities on a commercial scale is difficult and expensive; and because increased international inspections and scrutiny for a state, particularly if there is no compelling economic rationale for the program, could result in detection or otherwise undermine the weapon effort. In the long term, some participants recognized, the situation could be very different, with an expansion to states across the globe, the emergence of second generation suppliers of equipment, fuel and services, etc.

It was noted that the debate over risks today is in many ways similar to that in the 1970s, including expectations of dramatic growth in nuclear power; concerns about reprocessing and plutonium use; and perceptions of rising proliferation and terrorism threats. The differences were recognized as well, especially the fact that the risks from highly enriched uranium (HEU) are now seen as greater.[4] The risks are also increasingly seen to be emerging from unanticipated sources, including non-state actors and terrorists.

Some noted that this debate in the last few years has been influenced by the new interest in nuclear power and taken on an added dimension with renewed attention to disarmament. Although the prospects for disarmament were at the forefront of the debate on nuclear power in the 1940s and early'50s, it only recently has reappeared, reinforcing the need to strengthen nonproliferation efforts and raising the stakes of success. A nuclear-weapon-free world and the benefits of nuclear power will require measures to reduce risks of proliferation and terrorism that are more effective and efficient than those in use today.

[4] This perception is largely based on the spread of centrifuge enrichment technology by the A.Q. Khan network and, to the extent it may represent an overreaction, may be reconsidered in the future.

A Nuclear Renaissance?

Given these issues and challenges, there was some skepticism about the prospects for a global nuclear energy renaissance due to the need for expanded human and industrial capacity to support nuclear power growth, the need to replace retiring capability and other issues. However, there was a recognition that nuclear power would expand somewhat in the decades ahead with some states expanding capacity dramatically (e.g., China) and at least a few new states developing nuclear power programs. One participant said that speaking of a renaissance was surely exaggerated, but reflected an evident move toward the expansion of the number and geographical distribution of nuclear power production worldwide. It was also argued by some participants that, under the right conditions, a genuine renaissance could occur some decades from now.

Assessing Proliferation and Terrorism Risks

In the context of rising regional instability and conflict, along with increased incidents of global terrorism, in a dynamic, uncertain security environment, emerging nuclear and other weapons of mass destruction (WMD) threats—both proliferation and terrorism—are seen as growing dangers giving rise to increasing global insecurity. The risks of proliferation and terrorism today were seen to covers a wide range of possibilities. Among the challenges noted were:

- ongoing proliferation threats from Iran, North Korea, Syria and other states;
- emerging threats from non-state actors to acquire nuclear explosives or a "dirty bomb;"

- potential growth and expansion of nuclear energy, in particular to "newcomers" that will not have a developed nuclear infrastructure;
- emerging new suppliers, including non-state actors; and
- the possibility of moving to dramatically reduced numbers of nuclear weapons, leading to new requirements for the effectiveness of all aspects of nuclear safeguards and nuclear security.

These issues were exacerbated by problems with the NPT, including efforts to exploit Article IV to obtain a weapon capability or "hedge," the expanding workload of the IAEA with insufficient funding, etc.

Given the complexity of these issues, it was noted that risks and threats need to be better understood and calibrated if we are to design more effective nonproliferation and physical security responses. The discussion suggested that the risks to be assessed include the concrete links of these risks to civilian nuclear power programs; the differences between plutonium and HEU, as well as between open v. closed fuel cycles in this context; the comparative costs of managing any risks; and the comparative risks of the pursuit of nuclear growth v. the impact of not doing so in terms of energy security, environmental stewardship and other issues. In this context, there was some discussion of evaluation methodologies, such as that developed by the GenIV International Forum's (GIF's) Proliferation Resistance and Physical Protection (PR&PP) Working Group, in assessing threats and responses. The structured and transparent analyses of this sort were judged to be superior to alternate means to evaluate risks.

Addressing the Risks

It was widely recognized that the NPT and the international nuclear non-proliferation regime were faced with serious challenges. As it has in the past, the regime is evolving as threats have changed, several participants noted, as is evident in the case of safeguards. In the last decade and a half, the International Atomic Energy Agency has been transforming its safeguards system and adopting a fundamentally new approach to implementing safeguards based on the strengthening measures developed in the 1990s. Fundamental to the new approach to IAEA safeguards is information acquisition, evaluation and analysis along with inspections. The new approach is designed to provide an evaluation of the nuclear program of a state as a whole.

An effective, strengthened international safeguards system, with a strong focus on searching for undeclared nuclear materials and activities, was widely viewed as essential to provide confidence that shared nuclear technologies and expertise, as well as nuclear materials themselves, are not being diverted to nuclear-weapon programs. This will be especially important if the projected nuclear renaissance is fully realized, which many recognized would pose safeguards challenges due to such factors as increased numbers, types and geographical spread of reactors, the increased numbers and types of fuel cycles, including new fuel cycles, and increased global flows of nuclear materials.

In addition to strengthening safeguards and other traditional regime elements such as export controls, initiatives to address new and emerging threats, and unanticipated developments—

from the end of the cold war to the rise of terrorism—have been especially prominent in the last 15 years. Among these are critical initiatives involving threat reduction, detection and interdiction, such as the Proliferation Security Initiative and UNSC Resolution 1540. Beyond these and other programs and initiatives, the discussion highlighted several ideas that are now being considered, or rather reconsidered today to address proliferation and terrorism risks

Offering an assured supply of fresh nuclear fuel and spent-fuel take back to discourage the spread of enrichment and reprocessing technology are old ideas that are receiving new attention, which is driven by Iran's nuclear defiance and the renewed debate on international fuel cycle choices. Many noted that every state that seeks nuclear power does not need a dedicated enrichment program or a spent fuel reprocessing capability.

Interest in multinational fuel banks and centers and the provision of reliable fuel services have become central to thinking about addressing emerging challenges, even though many argue that they will not help with issues like Iran and North Korea. This interest can be seen in the call by President Obama for a new "framework for civil nuclear cooperation" that would meet global energy needs while reducing incentives for the spread of enrichment, reprocessing and other sensitive nuclear technologies.

Multinational or multilateral ownership has been proposed by former IAEA Director General Mohammed ElBaradei as a means to address this issue. One participant noted that the United States was leading by example on multinational approaches. Two new commercial enrichment ventures based on advanced gas centrifuge technology are being constructed in

the United States by foreign contractors. US companies will operate the plants but there will be no transfer of proprietary or proliferation sensitive technology to the United States. However, the limits of multinational approaches were noted by some, especially the inability of URENCO to protect its technology from A.Q. Khan, the proliferation problems with proposals to multinationalize Natanz, etc.

The difficulties of realizing these or any of the other proposals that have been put forward to minimize proliferation risks through reliable supply are significant and have bedeviled past efforts along these lines. In the end, the viability of current proposals depends ultimately on common interests (commercial, political, industrial, etc.). One participant argued that if Iran or other states that pursue sensitive nuclear technologies for weapon purposes, they should not be allowed benefit financially as a provider of nuclear services until adequate transparency and confidence are restored. Fuel banks and other mechanisms could facilitate such an approach.

Finally, new attention to another old idea—proliferation resistance—has grown and can be expected to grow in the years ahead. The hope of finding a way to make the peaceful uses of nuclear energy resistant to proliferation appears and reappears in the history of nuclear power. The concept of proliferation resistance has never been well defined and has usually been oversold. There is no consensus on what it means, but it clearly cannot mean "proliferation-proof." It was recognized there are no simple technological fixes or "silver bullets." There was a widely held view that advances in technology had less potential than advances in institutional measures, especially those approaches that depend on degrading the

quality of nuclear materials, although one participant argued on the basis of the international response to Iran's nuclear program that institutional measures were the "weak link" today.

In any case, some argued that there are benefits that may yet be realized from reactors and other facilities designed to minimize risks coupled with effective safeguards and other nonproliferation measures. The idea of proliferation-resistant small reactors with long-lived cores is among the ideas for addressing underlying proliferation concerns, while expanding nuclear power to the developing world and increasing the attractiveness and acceptability of nonproliferation efforts. One participant advocated the benefits of high temperature gas cooled reactors on proliferation resistance and other grounds. In these as in other cases, if proliferation resistance is to be real, it must be institutionally as well as technically based.

Safeguards by design, as well as security by design, appeared promising path to many participants. One participant argued that approaches to fuel cycle design, facility layout and physical protective measures can eliminate the feasibility of certain theft scenarios and make success extremely unlikely. As for state proliferation, the participant argued that such efforts could involve steps to track and locate nuclear material accurately and cheaply throughout the cycle; eliminate scenarios that are costly to address with external measures (i.e., additional guns, gates and guards); increase the difficulty of misusing a facility for proliferation and make it inaccessible to outsiders (and to insiders for unauthorized actions); enhance transparency and "safeguardability;" and increase the role of "passive" security and safeguards features. On the other hand, some participants raised cautions about the costs and acceptability. One participant stated that there was a need to demonstrate a "business case" for safeguards by design.

Implications for Nuclear Power

One participant argued that there was a need to engage the nuclear industry if there was to be a likelihood of ensuring that nuclear growth occurs in a way that does not increase proliferation and terrorism risks. In this view, nuclear power growth is developing now without US influence, which has waned because of the domestic nuclear power has not grown, the inability to address the back end of the fuel cycle and other issues. This, it was argued, could be troubling in the decades to come as a new generation of suppliers and states with nuclear power programs grew. Another participant noted US leadership in nonproliferation technologies and the possibility that this was one point of influence.

Several participants noted that the United States will not be able to continue to lead global nonproliferation efforts and to shape the growth of nuclear power as well as the global environment and energy debates without a robust US nuclear energy program. The President's call for a new generation of nuclear reactors and the need to come to terms with the back end of the fuel cycle were seen as critical in this context. Others highlighted the need for US industry to increase its capabilities to provide components manufactured in the United States, to expand enrichment and fuel fabrication and, in cooperation with the government, to offer fuel cycle services.

Some argued that fully integrating nuclear energy growth and nonproliferation, proliferation resistance and physical protection objectives was possible. The growing consensus on these

objectives and the growing concern about the potential impact of further proliferation on the industry was one reason for optimism

The Blue Ribbon commission led by Scowcroft and Hamilton were seen as going far beyond the need to find an alternative to Yucca, and the preeminent forum in the next years to address the back end of the fuel cycle, needed R&D and people and other issues in order to ensure the benefits of nuclear power and to promote nonproliferation. Addressing this issue is the critical missing element, or the final piece of the puzzle, it was argued.

Workshop on Nuclear Power Growth and Nonproliferation

Woodrow Wilson International Center for Scholars, Washington, DC

April 21, 2010

Agenda

9:00-10:00 am

Welcome and Keynotes

D. Poneman, Department of Energy

S. Fetter, Office of Science and Technology Policy

10:00-11:00 am

Panel I. A Nuclear Renaissance?

C. Ferguson, Federation of American Scientists

S. Squassoni, Center for Strategic and International Studies

11:00-11:15 am

Break

11:15 am-12:45 pm

Panel II. The Risks of Proliferation and Terrorism

J. Whitlock, Atomic Energy of Canada Limited

F. von Hippel, Princeton University

K. Budlong Sylvester, Los Alamos National Laboratory

12:45-2:00pm

Lunch

2:00-3:30 pm

Panel III. Addressing the Risks

J. Tape, US Member, Standing Advisory Group on Safeguards Implementation

Y. Kuno, Japan Atomic Energy Agency

J. Acton, Carnegie Endowment for International Peace

3:30-3:45 pm

Break

3:45-5:15 pm

Panel IV. Implications for Nuclear Power

A. Flint, Nuclear Energy Institute

J. Carbonnier, Commissariat à l'énergie atomique

5:15-7:00 pm

Reception