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Assurance of Supply: A New Framework for Nuclear Energy

The increase in global energy demands and pressing concerns over climate change are driving a potential expansion in the use of nuclear energy. Dozens of states have approached the International Atomic Energy Agency (IAEA) for guidance as they explore the possibility of building nuclear power reactors for the first time. With an expansion and spread of nuclear energy will come an expanded demand for nuclear fuel, and for the management of spent nuclear fuel. Where will the fuel supply for an expanded global reactor fleet come from? Will it remain in the hands of existing suppliers, with expanded capacity? Will new states develop their own national enrichment capabilities, adding to the number of states with the capacity to produce either fuel for nuclear power reactors or material for nuclear weapons? Or will multilateral nuclear fuel cycle facilities emerge to meet expanding demand? Many IAEA member states have expressed mounting concern over the risks that could be created by the further spread of technologies such as uranium enrichment or plutonium reprocessing—key technologies for the production of fuel for nuclear power reactors that could also be used to produce material for nuclear weapons.

The convergence of these realities points to the need to develop a new framework for the nuclear fuel cycle that provides reliable and predictable access to nuclear fuel and power reactors while strengthening the Nuclear Non-Proliferation Treaty (NPT) regime. Establishing a framework that is equitable and accessible to all users of nuclear energy acting in accordance with agreed nonproliferation norms will be a complex endeavor and should be addressed through a series of interlinked, progressive steps.

The first step would be to establish mechanisms that provide assurance of the supply of fuel for nuclear power reactors—and, as needed, assurance of the acqui-

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sition of such reactors. If states have assured access to fresh fuel for their nuclear power reactors, they will be less motivated to pursue own development of sensitive technologies for producing nuclear fuel. The second step would be to have future facilities for enrichment and reprocessing—the key technologies that make it possible to produce nuclear weapons material—under multilateral operation, rather than under purely national control. The third step would be to convert existing enrichment and reprocessing facilities from national to multilateral operations. In this context, it would be crucial to negotiate and implement a global, internationally verifiable treaty prohibiting the production of fissile material for nuclear weapons. Below we focus primarily on the first of these steps.

THE NEED FOR A NEW FRAMEWORK

The first notion of fuel assurances appeared in the Baruch Plan, a 1946 U.S. proposal to the United Nations to provide international oversight of atomic energy development. Some 30 years later, the 1976 international nuclear fuel-cycle evaluation looked at multilaterally owned and operated nuclear frameworks. And, 60 years after the Baruch Plan, a special event at the IAEA's general conference held in September 2006 focused on several new proposals for multilateral approaches, such as commitments to supply enrichment services, international nuclear fuel centers, and even multilateral control over all nuclear fuel-cycle facilities.

In the more than half-century since the Baruch Plan, dual-use material and technologies have spread, with attendant risks of proliferation and nuclear terrorism. Such nuclear threats affect both the future of peaceful uses of nuclear energy and the prospects for nuclear disarmament.

The spread of nuclear fuel-cycle facilities and technologies is motivated in part by states' interest in ensuring reliable fuel-cycle services through indigenous capability. This, then, is the challenge: what must be added to the existing market for fuel-cycle services to provide enough assurance of supply to convince states that there is no need to invest in their own indigenous fuel-cycle facilities?

This question goes to the heart of the IAEA's mission. Not surprisingly, the IAEA must balance the interests of all of its member states. It needs to adequately represent the needs and interests of developing states, of nuclear-supplier states, of states that are already relying on nuclear power, and of states that have plans to develop nuclear power in the future, all while minimizing the risk of nuclear proliferation, as stated in the IAEA Statute.[1]

THE ROLE OF FUEL ASSURANCES

Discussions both with nuclear supplier states and, more importantly, with consumer states have made abundantly clear that different states will choose different policies and solutions to meet their energy requirements. States' choices will depend on their specific situation, such as their geography, their technical abilities,

and the individual preferences of policymakers and members of the public. Thus, the IAEA must retain flexibility to respond to these demands.

The mechanisms for the assurance of supply are not intended to address commercial disagreements between suppliers and consumers, but rather to prevent interruptions of the supply of nuclear fuel due to a supplier's political considerations that are not related to nonproliferation.[2] These concepts are intended to address two particular challenges. The first is to prevent supply vulnerabilities from dissuading states from initiating or expanding nuclear power programs. The second is to reduce vulnerabilities that might create incentives for states to build new national enrichment and reprocessing capabilities.

In other words, an assurance-of-supply mechanism is envisaged solely as a means of backing up the operation of the current normally functioning market in nuclear materials, fuels, technologies, and so on. This would not be a substitute for the existing market, nor would it deal with disruptions of supply due to commercial, technical, or other failures. Moreover, in this context, no state would be asked or expected to give up or abridge any of its rights under the NPT.

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This point about rights is a critical one. In the debate outside of Vienna, the word "forgo" is used more often than not when describing the establishment of an IAEA fuel bank. Some officials and analysts have envisioned that states would agree to forgo their right to build enrichment and reprocessing facilities, and in return would gain access to an assured supply of nuclear fuel. In this day and age, however, few states are prepared to give up any rights, and one unexpected outcome of the proposals that have been framed in this way is that at least seven states have popped up saying that they may be interested in establishing enrichment plants in the future and are not prepared to compromise, dilute, or give up their right to do so. These states are Argentina, Australia, Brazil, Canada, Kazakhstan, Ukraine, and South Africa. This represents the greatest explosion of interest in enrichment in the nuclear age; it has been provoked in substantial part by well-intentioned efforts to prevent the spread of enrichment. Therefore, we need to frame the debate in a way that does not demand that states sign away their right to build enrichment and reprocessing plants, and that helps states feel comfortable that they can maintain their rights while making sovereign choices to rely, for the present, on the international market for nuclear fuel. These choices must be backed up by a multilayered mechanism that includes both assurances and a physical reserve of nuclear material. Just as the word "forgo"

has done more to undermine than to promote progress, loose talk of loopholes or an Achilles' heel in the NPT, or of a need to "reinterpret" the inalienable right to peaceful uses as recognized under Article IV of that treaty or in the Statute of the IAEA is at best unhelpful, at worst counter-productive.

As of summer 2009, three specific and more advanced fuel-assurance proposals were under discussion.[3] These proposals—the proposal of the IAEA Director-General on the establishment of an IAEA Low Enriched Uranium (LEU) bank, the Russian Federation Initiative to establish a reserve of LEU for supply to the IAEA for its member states, and the Multilateral Enrichment Sanctuary Project (MESP) of Germany—which are complementary, and which range from providing backup assurance of the supply of LEU, to establishing an IAEA-controlled LEU reserve, to setting up an international uranium enrichment center where the IAEA would have some role in the decision making.

STRUCTURING A NEW FRAMEWORK

A framework for assuring the supply of nuclear fuel could include three levels: first, reliance on the existing market, based on established commercial and other arrangements; second, backup commitments provided by suppliers of enrichment and fuel-fabrication services, and their respective governments, to be used when predetermined conditions and criteria are met following a disruption of supply for political reasons; and third, a reserve of low-enriched uranium stored in one or several locations under IAEA auspices, supported by agreements between suppliers of fuel-fabrication services and owners of fuel intellectual property rights, thus creating additional possibilities for fabrication.

The IAEA Statute, which entered into force on July 29, 1957, provides the IAEA with the authority to carry out the activities necessary to establish and operate a nuclear material bank (in this case, one containing low enriched uranium). Under Article III of the Statute, the Agency is authorized to acquire materials, services, and equipment, and to establish its own facilities and plants, in order to facilitate the practical application of nuclear energy for peaceful purposes. The legal authority for the receipt, custody, and supply of nuclear material lies, in particular, specifically in Article IX of the Statute, which provides for the supply of materials to the IAEA, and in Article XI, which outlines the authorized scope for IAEA projects.[4] In addition, Article X refers to the possibility of member states making available to the Agency services, equipment, and facilities that may be useful in fulfilling its objectives and functions.

IAEA Director-General Mohamed ElBaradei, in his statement to the Board of Governors in March 2009, said he was convinced that multilateral approaches to the nuclear fuel cycle have great potential to facilitate the expanded safe and secure use of nuclear energy for peaceful purposes, while reducing the risk of proliferation.[5] The best approach, he argued, would be to start with a nuclear fuel bank under IAEA auspices, based on the following principles: (1) that any such mechanism should be nonpolitical, nondiscriminatory, and available to all states that are

in compliance with their safeguard obligations; (2) that any release of material should be determined by nonpolitical criteria established in advance and applied objectively and consistently; and (3) that no state should be required to give up its rights under the NPT regarding any parts of the nuclear fuel cycle. The next steps, as noted earlier, would be to seek agreement that all new enrichment and reprocessing activities should be placed exclusively under multilateral control, and then to convert all existing facilities from national to multilateral control so that ultimately, as ElBaradei has said, no one country would have "the exclusive capability to produce the material for nuclear weapons."[6]

ESTABLISHING AN IAEA LOW ENRICHED URANIUM FUEL BANK

Among the leading proposals is one from the Nuclear Threat Initiative (NTI) that offers the IAEA $50 million on two conditions: (1) that IAEA member states raise an additional $100 million in material or cash donations, and (2) that the IAEA Board of Governors sets up an IAEA-controlled reserve of LEU as a last-resort supply in the event of a politically motivated supply disruption of nuclear fuel to an IAEA member in good standing with its safeguards obligations. All other criteria for the fuel bank under the NTI proposal are left to the IAEA to define. Thus far, the United States has provided $49.5 million, Norway has pledged $5 million (and paid $1.5 million), and other pledges have come from the United Arab Emirates ($10 million), the European Union (25 million Euros or about U.S.$33 million), and Kuwait ($10 million). The total will exceed the $100 million requirement once all the pledges are fulfilled. The NTI has extended its initial two-year deadline, which would have expired in September 2008, thus allowing more time for consensus to be built on the structure of the reserve and for the IAEA Board of Governors to take the decision for the establishment of such a bank. The following is a general description of how the bank would work.

The IAEA bank would contain a physical stock of LEU of standard commercial specification, with U-235 enrichment levels ranging up to 4.95 percent. This range of enrichment would provide the necessary flexibility to meet the requirements for subsequent fuel fabrication for most power reactors. The IAEA envisions making purchases of LEU using its standard procedures for open tender from vendors willing and able to provide the material free of conditions that conflict with the envisioned purpose of the fuel bank. The LEU would be made available to a consumer state at the prevailing market price at the time of supply, and the proceeds would be used to replenish the stock of LEU.

At current market prices, the $150 million pledged so far would be sufficient for the purchase of 60 to 80 tons of LEU and its delivery to the IAEA bank located in a host state. This would be sufficient for one full core of a 1000 to 1500 MW(e) power reactor or for three annual reloads, and would be sufficient to meet the electricity needs of two million average Austrian households for three years. The annual cost to operate the bank, which would be incurred by the IAEA, would depend on a number of factors, including storage costs and the costs of other

requirements associated with storage, such as safety and security measures. Ideally, such costs would be picked up by the host state.

The Russian Federation has proposed separately to establish an LEU reserve that the IAEA could draw on. Russia has indicated that it will create a physical reserve of 120 tonnes of uranium, in the form of $UF_{6,}$ with an enrichment of 2.0 percent to 4.95 percent, of which at least 40 tonnes have an enrichment of 4.95 percent. Russia has committed to provide LEU that would meet the latest commercial specifications, and any future evolution of those standards.

The Russian Federation would, upon notification from the Director-General of the IAEA, deliver the LEU to the IAEA in St. Petersburg for supply to eligible IAEA consumer state(s). Eligible states would be those states for which the IAEA has drawn the conclusion that there has been no diversion of declared nuclear material and concerning which there are no issues under consideration by the IAEA Board of Governors relating to the application of IAEA safeguards. The LEU could be transferred to a non-nuclear-weapon state only when it has brought into force an agreement with the IAEA requiring the application of safeguards on all its peaceful nuclear activities. These criteria will need to be approved by the IAEA board. Russia has committed to issue all necessary export controls and other authorizations, "such that the shipment of material out of the country at the request of the Agency is guaranteed."[7] This would include the timely transfer of ownership to the IAEA for subsequent supply to an eligible member state, and arrangements for the physical shipment of the LEU out of Russian territory. The Russian Federation also would arrange for the prompt issuance of all necessary authorizations and licenses for the import of international licensed transport containers for the LEU, as well as for their transport within and from the territory of the Russian Federation. The Russian Federation would bear all expenses relating to the storage and maintenance of the LEU prior to notification by the Director-General of an impending shipment. The recipient country would pay the IAEA in advance for the specific quantity of LEU at the prevailing market price, and the IAEA would use the money to pay Russia to replenish the reserve.

It has been proposed, subject to the Board of Governors' approval, that an IAEA member state experiencing a disruption of its fuel supply would be required to meet certain conditions to receive fuel from an IAEA fuel bank. The supply of LEU from the bank or the reserve would be permitted to an IAEA member state only if (1) the state is experiencing a disruption of LEU fuel supply to a power reactor due to nontechnical, noncommercial reasons; (2) the IAEA has concluded in the most recent annual Safeguards Implementation Report that the state has not diverted declared nuclear material and that no specific report relating to problems with safeguards implementation is under consideration by the Board of Governors; and (3) the state has brought into force a safeguards agreement that applies to the LEU being supplied through the IAEA bank.

Any other member state could also choose to establish a national LEU reserve that the IAEA could draw upon, subject to that state's own criteria as approved by

the board. (The United States, for example, is also establishing an LEU reserve of some 300 tons, down-blended from up to 17 metric tons of highly enriched uranium [HEU]no longer needed for military purposes.[8]) However, the LEU bank reserves managed by the IAEA itself, as envisioned in the NTI proposal, would be subject only to criteria and rules agreed on by the IAEA Board of Governors; as currently envisioned, it would in principle be possible for a state that does not have full-scope safeguards to draw on the reserve, as long as it had met the criteria outlined above.

How would the decision be taken to go forward with a shipment of fuel? It has been proposed that the IAEA Board would agree in advance to follow this process:

- A consumer state[9] that is experiencing a disruption in the supply of LEU that is not related to technical or commercial considerations and that fulfills the prescribed criteria, would submit a request to the Director General to provide a specified amount of LEU for a power reactor, along with an explanation of the circumstances in support of its request;
- The Director-General would assess the nature of the disruption and determine whether the consumer state has fulfilled the criteria established by the Board and is thereby eligible to purchase LEU from the IAEA.
- The Director-General, using a model agreement, would conclude an agreement with the consumer state requesting the LEU. The agreement would specify the obligations of the IAEA and of the consumer state, including all issues relating to the amount and specification of the LEU, liability, safeguards, and the cost of the LEU (including delivery, transport, and insurance costs) that would be paid in advance to the IAEA.

Following the entry into force of the above-mentioned agreement, the Director-General would authorize the transfer of the LEU to the consumer state.

The Director-General would keep the Board informed throughout the entire process. Note that there would be no requirement for consumer states to sign up ahead of time or to forgo any rights; the reserve would simply be available to be drawn upon if needed, reducing states' incentives to make the large investments required to develop their own enrichment capacity.

Why the focus on a bank of enriched uranium in the form of UF_6 and not on fuel fabrication? According to the latest IAEA sources, there are now 13 enrichment facilities in 9 states versus 34 fabrication plants in 18 states.[10] This shows that fuel-fabrication services are more widely dispersed than enrichment services, thus justifying an initial focus on supply assurance of LEU and for fuel fabrication to be considered at a later stage. Moreover, attempting to establish a bank of fabricated fuel would be extremely difficult, as each reactor design uses a different set of fuel designs, and each fabricator has intellectual property in the particular fuel designs it fabricates; therefore, to have prefabricated fuel suitable for every reactor in the world would be prohibitively expensive. As noted earlier, however, the IAEA secretariat has explored concepts in which there would be prior agreements among the

fabricators to step in and provide fabrication services in the event of a disruption from another supplier.

The bank would provide enriched uranium rather than natural uranium for two reasons: first, most of the world's reactors use enriched uranium, and second, natural uranium is available from a far wider array of sources since it is mined in dozens of countries. Currently, 48 nuclear power plants (11% of the world total) use natural uranium (44 pressurized heavy water reactors plus 4 MAGNOX reactors) and 388 nuclear power plants (89% of the world total) use enriched uranium.[11]

Germany has offered another proposal, suggesting that the international community set up a multilateral enrichment sanctuary project (MESP),[12] which would involve a group of interested states contributing the money, technology, and expertise to establish a new enrichment facility in a state that has not developed its own uranium enrichment technology. The MESP would buy its centrifuges using a "black box" model, in which the state that provided the centrifuges would control and operate the centrifuge cascades while the other members of the group of interested states would control all other aspects of the operations. The MESP would provide enrichment services to the group and to the market, and could also provide LEU for an IAEA bank. It would be run on a commercial basis without government subsidies, and would have to operate on a profit-making basis in order to sustain its operations as a new producer. This would represent a new step in the direction of multinational control of enrichment facilities.

A CAUTIOUS APPROACH

To reiterate, establishing a new framework for the nuclear fuel cycle is a complex endeavor that will need time to develop. The IAEA Secretariat is working to lay out the necessary legal and technical specifics, and to facilitate a full, frank, and comprehensive discussion with both consumer and supplier states. This preparatory work should make it possible for states to decide whether to establish an IAEA LEU bank or other multilateral mechanisms in the near term.

In his 1953 Atoms for Peace speech, President Dwight D. Eisenhower articulated a vision, shared by many world leaders, that would enable humanity to make full use of the benefit of nuclear energy while minimizing its risk. This vision led to the establishment of the IAEA. Much has changed since that time, and it is appropriate to take stock now of our successes and failures. Most important, we must resolve to take whatever actions are required, including new ways of thinking and unconventional approaches, to ensure that nuclear energy remains a source of hope and prosperity for humanity as envisioned in the NPT, and not a source of increased danger.

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1. The IAEA Statute is accessible at http://www.iaea.org/About/statute.html (accessed July 14, 2009).
2. A summary of some 12 existing fuel assurance proposals is available on IAEA's website, http://www.iaea.org/NewsCenter/Focus/FuelCycle/index.shtml (accessed July 13. 2009). See also

International Atomic Energy Agency, *In Focus: Revisiting the Nuclear Fuel Cycle* (Vienna: IAEA, March 6, 2009).

3.See Tariq Rauf and Zoryana Vovchok, "A Secure Nuclear Future,"*IAEA Bulletin* (September 2009), Vol. 51, No. 1, p. 11.
http://www.iaea.org/Publications/Magazines/Bulletin/Bull511/51104871013.pdf.

4. Other relevant articles include III.A.1, III.A.2, III.A.7, and III.C.

5. Mohamed ElBaradei, "Introductory Statement to the Board of Governors," March 2, 2009, http://www.iaea.org/NewsCenter/Statements/2009/ebsp2009n002.html (accessed July 13, 2009).

6. Mohamed ElBaradei, "Reviving Nuclear Disarmament," conference on Achieving the Vision of a World Free of Nuclear Weapons, Oslo, Norway, February 26, 2008.

7. Russian Federation, "Establishment, Structure, and Operation of the International Uranium Enrichment Centre," INFCIRC/708 (Vienna: International Atomic Energy Agency, June 8, 2007), http://www.iaea.org/Publications/Documents/Infcircs/2007/infcirc708.pdf (accessed July 14, 2009).

8. See IAEA document, INFCIRC/659 (September 29, 2009), http://www.iaea.org/Publications/Documents/Infcircs/2005/infcirc659.pdf; and Fact Sheet on U.S. HEU for a Nuclear Fuel Reserve, http://vienna.usmission.gov/np_nuclear.html, accessed July 15, 2009.

9. As noted above, only an IAEA member state could request supply of LEU.

10. International Atomic Energy Agency, *Nuclear Fuel Cycle Information System, A Directory of Nuclear Fuel Cycle Facilities* (2009 Edition), IAEA-TECDOC-1613 (Vienna: IAEA, 2009). See table 14 for a list of states with enrichment plants, and tables 17-22 for states with fuel fabrication plants.

11. This includes 92 boiling water reactors or BWRs, 2f ast breeder reactors, or FBRs, 14 gas cooled reactors, or GCRs, 16 light water graphite reactors, LWGRs (including 12 Chernobyl-style, Russian-design reactors, and four very small Russian reactors at the Bilibino site), and 264 pressurized water reactors, or PWRs. One Argentine pressurized heavy water reactor, or PHWR operates with very slightly enriched uranium, i.e. 0.9 percent U-235 instead of natural uranium's 0.7 percent, but should the supply of enriched material be interrupted, it could operate on natural uranium.

12. See Federal Republic of Germany, "The Multilateral Enrichment Sanctuary Project: A Fresh Look at Ensuring Nuclear Fuel Supply," INFCIRC/735 (Vienna: IAEA, September 25, 2008), http://www.iaea.org/Publications/Documents/Infcircs/2008/infcirc735.pdf (accessed July 13, 2009).