

## Multilateral Approaches to the Nuclear Fuel Cycle

### SUMMARY

- Proposals to multilateralize the nuclear fuel cycle date back to the 1950s, but they acquired new salience as of 2003.
- Most proposals that have emerged since 2003 are focused on guaranteeing against a cut-off in supply of nuclear fuel to states for reasons other than proliferation concerns.
- States hold a range of views on these fuel-supply proposals, and only two proposals have been actively considered by the International Atomic Energy Agency (IAEA) board of governors.
- One of these, a reserve of low-enriched uranium (LEU) fuel at Angarsk, Russia, was recently agreed to between the IAEA and Russia.
- The board of governors has also discussed an LEU fuel bank that would be held by the IAEA, with financing from the Nuclear Threat Initiative and several governments.
- Although decisions about fuel supply are not formally within the remit of the NPT review process, the question has mirrored larger debates about nonproliferation and disarmament and it is sometimes perceived as an effort to erode Article IV rights. It may arise in that context at the Review Conference.

### THE ISSUE

Since 2003, there has been significant attention paid to the questions of whether and how to multilateralize the nuclear fuel cycle. Discussion of this question is long standing, reaching back to the first few years of the nuclear era, and emerging periodically in subsequent decades. The tenacity of the issue reflects its importance. The difficulty in addressing it reflects the degree to which it touches on both security and economic interests of states.

In its most developed form, a multilateralized fuel cycle would mean that the production and disposal of nuclear material took place under international controls—for all states, including those that now have their own fuel production and disposal capabilities. This is the long-term goal that Dr. Mohamed ElBaradei, then director-general of the IAEA, articulated in an October 2003 article:

...it is time to limit the reprocessing of weapons-usable material (separated plutonium and high-enriched uranium) in civilian nuclear programmes, as well as the production of new material through reprocessing and enrichment, by agreeing to restrict these operations *exclusively to facilities under multinational control*. These limitations would need to be accompanied by proper rules of transparency and, above all, by an assurance that legitimate would-be users could get their supplies.<sup>13</sup> [emphasis added]

The near-term barriers to such an arrangement are substantial: unwillingness among many states to surrender this sensitive industrial activity to multilateral control; countervailing interests of the nuclear industry; and skepticism that a truly nondiscriminatory arrangement could emerge and persist.

Partly because a discussion of true multilateralization seemed premature, the discussions that were prompted by Dr. ElBaradei's comments eventually narrowed to the question of assured supplies of nuclear fuel: is there a way to assure that countries that have civilian nuclear programs, and that buy fuel in the global market, can be confident that their fuel supplies will not be cut off for political reasons? And is that achievable in the short term, even if the goal of broader multilateralization is not yet possible? Numerous proposals have come forward that attempt to answer both questions affirmatively.

### BACKGROUND: THE SUPPLY OF NUCLEAR FUEL

Proposals for fuel assurances grew out of, and would be implemented in, an active commercial market for nuclear fuel; it may be useful briefly to characterize the products and structure of that market:

#### Fuel-cycle facilities: what is needed for nuclear power?

For most nuclear reactors used in energy production, natural uranium must be enriched and placed into fuel assemblies that then form the reactor

<sup>13</sup> This was one part of a three-part proposal by Dr. ElBaradei. The other two concerned (1) the need to develop proliferation-resistant nuclear-energy systems; and (2) multilateral approaches to handling spent fuel and waste management. Mohamed ElBaradei, "Towards a Safer World," *The Economist*, October 16, 2003.

core.<sup>14</sup> The uranium-fuel-production process entails several steps:

- *Mining and milling* of the uranium, yielding “yellowcake” ( $U_3O_8$ ).
- *Conversion* of the yellowcake to uranium hexafluoride ( $UF_6$ ).
- *Enrichment* of the  $UF_6$  to increase the proportion of  $U_{235}$  isotopes to 3 to 5 percent (low-enriched uranium or LEU). (It is this stage that is considered most sensitive, in that the enrichment technologies can be used to produce fuel for civilian power plants or for nuclear-weapon development).
- *Fabrication of the reactor fuel*, by converting the enriched uranium to uranium dioxide ( $UO_2$ ), forming it into fuel, and loading it into fuel rods.

In addition to these “front-end” steps, an operating reactor will produce spent fuel, which must be disposed of or otherwise managed safely. With *reprocessing*, this spent fuel can be a further source of reactor fuel.

### The nuclear-fuel market

Thirty countries currently have operating nuclear-power reactors, with a combined total of 439 reactors worldwide. In some cases, these programs are owned and operated by states, either directly as a national enterprise, or indirectly through equity ownership; fuel may be produced for domestic consumption primarily, but also for the global market. In other cases, the power is produced largely in the private sector, for commercial purposes. In all cases, however, the government is heavily involved in the regulation of planning, construction, and operation of nuclear-power plants, and also monitors the international trade that relates to those plants.

State and commercial producers of nuclear power may purchase one or more of front-end fuel-cycle products from the global market. They buy fuel at all four stages of the uranium-fuel-production process, negotiating directly with sellers or brokers. Analysts both inside and outside the industry say that the global nuclear fuel market is healthy and functions effectively (and many want to ensure that

any fuel-supply arrangements do not disrupt the existing market).

The production of uranium fuel for the global market is concentrated in a relatively small number of companies and countries:

- *Mining and Milling*. Eight companies accounted for over 80 percent of total world production of  $U_3O_8$  as of 2007, the most recent year for which we have data. The eight produced 85 percent of a total production of 109 million pounds. Companies based in Australia and Canada alone produce over 40 percent; other countries with substantial yellowcake production include Kazakhstan, Namibia, Russia, and Uzbekistan.<sup>15</sup>
- *Conversion to  $UF_6$* . Five companies account for most of the conversion services on the global market. Their facilities are in Canada, France, Russia, the United Kingdom, and the United States.<sup>16</sup> Brazil, China, and Iran also have conversion facilities.
- *Enrichment*. Four companies produce most enriched uranium for global markets, operating in France, Germany, the Netherlands, Russia, the United Kingdom, and the United States. Other countries with enrichment capabilities are Brazil, the Democratic People’s Republic of Korea (DPRK), India, Iran, Israel, and Japan.
- *Fuel fabrication*. Different reactors require different fuel assemblies, and production processes are therefore more diverse and facilities somewhat more widespread. Locations for major fabrication activities for the global market include France, Germany, Kazakhstan, Russia, and the United States,<sup>17</sup> although there are also operating fabrication facilities in more than ten other countries, including China, India, Japan, and the United Kingdom.

These figures suggest two things about the context for proposals to multilateralize the fuel cycle: very few countries have all stages of the fuel cycle within their own borders—which means that most are purchasing at least some fuel services or products from the global market; and commercial conversion and enrichment services are concentrated in a few countries.

14 Heavy water reactors, such as those in Canada and India, use natural uranium; there are fewer than thirty of these reactors worldwide. Some reactors are also fueled by a combination of uranium and plutonium that has been separated from spent fuel.

15 See, Cameco, “Uranium 101,” 2008, available at [www.cameco.com/uranium\\_101/](http://www.cameco.com/uranium_101/).

16 WISE Uranium Project, “World Nuclear Fuel Facilities,” January 27, 2009, available at [www.wise-uranium.org/efac.html](http://www.wise-uranium.org/efac.html).

17 Ibid.

## PROPOSALS FOR FUEL ASSURANCES

In 2004, the director-general of the IAEA appointed a diverse experts group to explore options for multilateral approaches to both front- and back-end fuel-cycle activities. The experts group released a comprehensive and rather complex report in February 2005.<sup>18</sup> It analyzed options ranging from fully multilateral arrangements, which put all fuel production and waste management under international control, to minimally disruptive arrangements that relied first on assurances by suppliers.

With this increasing attention to multilateral fuel-cycle approaches, states and two nongovernmental organizations began proposing ways to guarantee the supply of uranium fuel. By 2009, there were eleven such proposals for fuel-assurance arrangements. States contributing these proposals (some as sole author, some with other countries) included Austria, France, Germany, Japan, the Netherlands, Russia, the United Kingdom, and the United States. It is worth noting that most of these are supplier states, i.e., that they are home to commercial fuel-supply capabilities. The World Nuclear Association (WNA), an industry group, also put a proposal forward, as did the Nuclear Threat Initiative (NTI), a private foundation. Norway, the United Arab Emirates, and the European Union committed financial support to the NTI project (discussed below), and in that sense are part of its proposal.

The proposals share some similarities—e.g., most include an active role for the IAEA—but are different in other ways that make comparison somewhat complex and lengthy. For this reason we do not discuss all the proposals here. It may be helpful, nonetheless, to summarize the key variables at play as plans for fuel-supply arrangements are developed. Six questions are particularly important:<sup>19</sup>

1. **What is being assured?** Is it access to yellowcake, to uranium hexafluoride, to enriched uranium, and/or to fabricated fuel for specific reactors? Most existing proposals focus on enriched uranium.
2. **To whom are assurances being directed?** Is it to all states that have, or want to have, nuclear power facilities? Only those that do not currently have enrichment or reprocessing capabilities? As suggested above, most proposals are directed at new nuclear-power states, although they do not necessarily preclude access by any nuclear-power producer.
3. **How would fuel access be assured?** Possibilities incorporated into existing proposals include the following:
  - back-up agreements by governments and/or suppliers (such that one supplier could step in, if another were prohibited from delivering contracted fuel);
  - fuel banks, either virtual or real;
  - fuel-leasing arrangements;
  - joint investment in multilateral enrichment activities (whereby interested states become co-owners of an enrichment facility, and have access to enriched fuel by virtue of that co-ownership);
  - an extraterritorial multilateral fuel-production center, under the ultimate authority of the IAEA.
4. **Who would assure the access?** There are three possibilities: some combination of existing commercial fuel producers; governments or consortia of governments; and/or the IAEA. Typically the multilateral proposals set out a prominent role for the IAEA.
5. **Under what conditions could a state access the fuel?** The fundamental condition would be that an existing contract was not being filled, due to political disagreements between the supplier state and the customer state. Existing proposals tend to agree that any state accessing the fuel-supply mechanism would need to comply with NPT obligations or ones similar to those of the NPT. Proposals diverge over whether these customer states would have to have signed the Additional Protocol and/or agreed to forgo the development of enrichment capabilities.
6. **Who decides on eligibility?** The question here is who decides whether a state is eligible to access the fuel assurance mechanism—whether the

<sup>18</sup> IAEA, "Multilateral Approaches to the Nuclear Fuel Cycle," Expert Group Report submitted to the Director General of the IAEA, INF/CIRC/640, February 22, 2005. Available at [www.iaea.org/publications/documents/infcircs/2005/infirc640.pdf](http://www.iaea.org/publications/documents/infcircs/2005/infirc640.pdf).

<sup>19</sup> See Yuri Yudin, *Multilateralization of the Nuclear Fuel Cycle: Assessing the Existing Proposals* (Geneva: UNIDIR, 2009). Most of the proposals can also be found on the IAEA website, available at [www.iaea.org](http://www.iaea.org).

supply disruption is indeed due to political factors; and whether the customer state meets the conditions of the fuel-supply arrangement. If producers or governments are providing the fuel assurance, then presumably it is they who would decide to whom this decision-making authority is delegated. If the IAEA were the guarantor, then the determination of eligibility would presumably be with the IAEA, likely the director-general, within the context of guidelines from the board of governors.

The latter two questions go to the heart of states' disagreements about both current attention to fuel-assurance proposals, and the nonproliferation regime more broadly.

## THE SITUATION TODAY

### National and multinational initiatives

Several proposals, essentially national or multinational, do not require approval by the IAEA or other international bodies.

**International Uranium Enrichment Centre (IUEC) at Angarsk.** Led by Russia, the center would, as a "commercial joint stock company," guarantee access to enriched uranium for participating organizations. The IUEC was officially formed in May 2007 when Kazakhstan joined. The original intent was that the IUEC would be "oriented chiefly to States not developing uranium enrichment capabilities on their territory." Moreover "in so doing, the Russian side will not transfer to IUEC participants the uranium enrichment technology or information that constitutes a State secret."<sup>20</sup> (It is possible that these terms have changed somewhat, although not in any readily available open-source document.) Armenia and Ukraine are also said to be considering the IUEC.

**US fuel bank.** Another proposal that does not depend on international action is the US plan to establish a fuel bank of seventeen metric tons of LEU, down-blended from highly enriched uranium (HEU) surplus. The fuel bank would be available only to states that forego enrichment and reprocessing. The down-blending is expected to be completed this year.

### Multilateral initiatives

At the multilateral level, two suggestions for fuel assurances have been developed to the point where they received active review from the IAEA board of governors in 2009. These are the proposal for an IAEA LEU fuel bank (originating with NTI); and the project of a fuel reserve at Angarsk, proposed by Russia. The other proposals continue to be elaborated. In general, most advocates of guaranteed fuel supplies argue that the suggested arrangements are not mutually exclusive, and in fact may complement and reinforce one another.

**IAEA LEU fuel bank.** In September 2006, the idea of an agency-controlled LEU fuel bank was proposed by NTI, which also pledged financial support. The fuel stockpile would be controlled by the IAEA, which would make decisions about its dispersal. Over \$150 million has been dedicated to the creation of this stockpile, by NTI, the US, Norway, the United Arab Emirates, the European Union, and the UK. According to a 2009 article in the IAEA Bulletin, "...any Member State could request supply when its LEU supplies are disrupted for reasons not related to technical or commercial considerations, it has brought into force a safeguards agreement that applies to any LEU supplied from the IAEA bank, has a conclusion on peaceful use / non-diversion of nuclear material in the latest IAEA Safeguards Implementation Report, and no specific safeguards implementation issues are under discussion in the IAEA Board of Governors."<sup>21</sup> Although the agency secretariat was closely involved in developing this proposal and had strongly supported it under Director-General ElBaradei, to date the fuel bank has not been approved by the board of governors. Its status is unclear at this point.

**LEU fuel reserve at Angarsk,** from which fuel could be made available, under IAEA auspices and control, to IAEA member states. The IAEA board of governors approved this arrangement in November 2009, authorizing the director-general to conclude agreements with Russia, and future agreements with member states that it considers eligible for the LEU supply. At the end of March, the IAEA and

20 IAEA, *Communication Received from the Resident Representative of the Russian Federation to the IAEA on the Establishment, Structure and Operation of the International Uranium Enrichment Centre*, IAEA doc. INF/CIRC/708, June 8, 2007.

21 IAEA, "A Secure Nuclear Future," 2010, available at [www.iaea.org/Publications/Magazines/Bulletin/Bull511/51104871013.html](http://www.iaea.org/Publications/Magazines/Bulletin/Bull511/51104871013.html).

Russia signed an agreement establishing the fuel reserve—the first such fuel bank created.

According to the Russian proposal,<sup>22</sup> this fuel reserve would be “a guaranteed physical reserve of 120 tons of LEU, in the form of UF<sub>6</sub>, with an enrichment level ranging from 2.0 per cent to 4.95 per cent, which will be stored at the International Uranium Enrichment Centre [IUEC—see above] under IAEA safeguards which will be financially covered by Russia for the use of the member States of IAEA experiencing a disruption of LEU supply [for reasons other than commercial or technical ones].” The criteria are the same as those for the IAEA LEU fuel bank, except for the requirement that a requesting state must be a non-nuclear-weapon state and a member of the agency, which has placed all of its peaceful nuclear activities under IAEA safeguards. According to a recent report, “About one-third of the site’s planned stockpile would be ready for purchase before the end of 2010.”<sup>23</sup>

#### FUEL ASSURANCES AND THE NPT REVIEW CONFERENCE

The question of fuel assurances has been controversial in discussions at both the IAEA board of governors and in the NPT review process. In the November 2009 meeting of the board of governors, even though the next steps on the LEU fuel reserve at Angarsk were approved, eight states voted against it, and three abstained—suggesting substantial reservations about establishing even this level of fuel arrangement. The range of opinion on the fuel-assurance proposals—and on the fact of their consideration at this time—has reflected the considerably different interests held by states. It has also mirrored larger debates, notably about nonpro-

liferation and disarmament commitments, which take place in the NPT context.

To advocates of fuel-assurance arrangements, the implementation of one or more of these proposals would be valuable in its own right, and also represent progress toward the long-delayed process of multilateralizing the fuel cycle. To critics, the very development of the proposals has been flawed, emerging out of the concerns of supplier states, prioritizing fuel assurances above other pressing needs, and creating the possibility of a process that leads to an erosion of Article IV rights<sup>24</sup>—and not necessarily to a truly multilateralized fuel cycle.

The importance of these issues to the 2010 NPT Review Conference is not entirely clear, although debates at the preparatory committees suggest their continuing salience. But the discussion may be entering a new phase: The IAEA’s focus on multilateralizing the fuel cycle was driven substantially by Dr. ElBaradei’s commitment to it. Whether his successor, Director-General Yukiya Amano, will take it up, or whether fuel assurances will retreat as an important topic at the IAEA, is uncertain.

Moreover, the proposals that appear politically feasible, including the recently approved Angarsk fuel reserve, may have relatively little effect on states’ decisions about whether and how they develop nuclear power. Nor does it seem likely that there will be a large demand for these guaranteed fuel supplies: as noted earlier, the market works well and the denial of fuel supplies for political reasons is rare. Thus if considered only in terms of direct consequences, the question of fuel assurances may have limited relevance to the central challenges facing the NPT and the Review Conference itself.

22 The Russian paper was prepared for the 2009 PrepCom, June 2009, UN doc. NPT/CONF:2010/PCIII/WP.25.

23 Global Security Newswire, “Agreement Signed for First International Nuclear Fuel Bank,” March 30, 2010, available at [www.globalsecuritynewswire.org/gsn/nw\\_20100329\\_6830.php](http://www.globalsecuritynewswire.org/gsn/nw_20100329_6830.php).

24 Article IV of the NPT states that “Nothing in this Treaty shall be interpreted as affecting the inalienable right of all the parties to the Treaty to develop research, production and use of nuclear energy for peaceful purposes without discrimination and in conformity with Articles I and II of this Treaty.” *Treaty on the Non-Proliferation of Nuclear Weapons*, Article IV. The full text of the treaty is in Annex I of this report.