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Multilateral Nuclear Fuel Supply Guarantees and Spent Fuel Management: What Are the Priorities?[1]

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Introduction

Expectations for a worldwide expansion of nuclear energy have raised fears that states could potentially procure sensitive technologies used to manufacture nuclear weapons or explosive devices.

To cope with this problem, some have advocated that enrichment and reprocessing facilities be constructed and operated under multilateral arrangements. Such an approach is generally viewed as effective in ensuring safe and reliable access to nuclear fuel and services at competitive market prices while strengthening the nuclear nonproliferation regime by removing incentives for countries to develop indigenous fuel cycle capabilities.

It is interesting to note that all proposals for multinational fuel cycle facilities have thus far originated from "supplier states." If multilateral fuel cycle arrangements have attracted only limited interest from "consumer states," it must be in part because the existing market for enrichment services has been operating reliably. Otherwise, potential buyers would have explored more actively new ideas for ensuring fuel supply. Clearly, something more than market reliability is at issue here. If some consumer states fear that fuel supply could be disrupted for purely political reasons, others seem to fear that multilateral supply arrangements could serve as a pretext for depriving them of their rights to construct and operate fuel cycle facilities domestically.

This paper posits that further improving the reliability of fuel supply is best achieved by giving priority to fuel leasing contracts, coupled with long-term generic export licenses, and last resort multilateral fuel supply arrangements. These arrangements are easier to implement in the short term, rather than much more complex multinational enrichment facilities. For

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neighboring countries starting nuclear power programs, setting up a fuel procurement consortium would provide safer and better fuel supplies than their individual participation in a multinational enrichment facility.

Regarding the back-end of the fuel cycle, this paper argues that developing multinational spent fuel-storage and geological disposal facilities will be relegated to the distant horizon due to the prevailing “Not-In-My-Backyard” syndrome. This is regrettable. Yet, as long as impediments to multinational spent fuel management remain high, it is most urgent to strengthen the International Atomic Energy Agency’s (IAEA’s) verification authority and improve the likelihood of prompt and firm UN Security Council action when a state is found to be in non-compliance with its IAEA safeguards or Nuclear Nonproliferation Treaty (NPT) obligations.

The Front-End

It is imperative for any utility that has invested in nuclear power plants (NPPs) to have the highest assurance that nuclear fuel will be supplied in a timely manner and at a fair market price to ensure that the plants operate without interruption. Almost all non-nuclear-weapon states (NNWSs) have thus far relied on the international nuclear fuel supply market to fuel their electrical NPPs. This dependence on the market is true even for countries that rely on nuclear energy for more than 30 percent of their total electricity production.

There is not a single example in history when a state with a Comprehensive Safeguards Agreement (CSA) in force was obliged to shut down its NPP due to the denial of nuclear fuel shipments. That said, today’s fuel supply industry is an oligopoly. Many electrical utilities have not forgotten that during the mid-1970s there was a cartel of uranium suppliers and a single supplier of enrichment services to Western states which, at one point in time, either did not accept new orders or imposed highly restrictive commercial conditions. The situation is much improved today, with well-established competition between suppliers.

Yet the fact that states with less than impeccable nonproliferation records could argue that they need to domestically produce low-enriched uranium (LEU) has recently raised new proliferation concerns. Indeed, once a country operates a uranium enrichment facility (e.g., based on the gas centrifuge process) and either has an indigenous conversion plant or a stockpile of UF6, it is technically in a position to produce high-enriched uranium (HEU) suitable for nuclear weapons. High-enriched uranium cannot be produced in a commercial enrichment plant (i.e., one normally limited to producing uranium with less than 5 percent U-235) under IAEA safeguards without being detected. However, a commercial enrichment plant could potentially be quickly reconfigured to produce HEU if the state where the facility is operating withdraws from the NPT. There is also a risk that a small, undeclared replicate of the enrichment facility (based on the same domestic technology) could be operated clandestinely. Both Libya and Iran have been able to work for over 20 years on the development of centrifuge enrichment without detection by the IAEA, prompting increased international awareness that this is more than a theoretical possibility.

It is therefore urgent to develop a concept that would guarantee reliable access to fuel for nuclear power reactors in NNWSs while providing maximum protection against the risks of nuclear proliferation.

In a country like Belgium, which relies on NPPs for 55 percent of its total electricity production, security of fuel supply is essential. To secure fuel supply, a combination of short-, medium-, and long-term contracts are concluded with as many suppliers as possible, together with strategic stockpiles in various forms and locations.

Of course, it is true that the perceived risk of supply disruption for purely political reasons may be smaller in Belgium than in some other countries. This concern must be properly addressed. In my view, the best way to do so would be for supplier states to provide what I have described[3] as long-term “generic export licenses.” These licenses consist of a bilateral agreement between the consumer and supplier states whereby the latter would provide a binding export license for nuclear fuel as long as specified nonproliferation, safety, and security conditions are met by the recipient state. It would be the responsibility of the IAEA Director General to confirm that these conditions are met.

Multilateral Approaches

a) Multinational Fuel Procurement Arrangements

It is virtually impossible for an electrical utility envisaging the construction or operation of its first NPP to diversify its fuel supply sources. It will therefore likely have to store on-site a strategic reserve of fabricated fuel assemblies proportionally larger than what is necessary for an electrical utility operating a significant number of NPPs. Alternatively, it may be useful for states constructing their first NPPs within the same region, such as those belonging to the Gulf Cooperation Council (GCC), to establish a common multinational fuel procurement company. Given its size, the creation of such a company would be in a better commercial position to diversify its fuel supply sources. Moreover, multinational ownership would allow the company to limit the potential disruption of fuel supply for political reasons. Collaboration in fuel

[3] P. Goldschmidt, “Mechanisms to Increase Nuclear Fuel Supply Guarantees,” Paper presented at the Carnegie International Nonproliferation Conference, November 7-8, 2005, http://www.carnegieendowment.org/static/npp/2005conference/presentations/Goldschmidt_fuel_supply.pdf.

procurement would be more feasible and economic than participation in multinational *enrichment* facilities.

b) Multinational Enrichment Facilities

Contrary to conventional wisdom, it is not necessarily in the interest of a state or company with a small nuclear program to become a minority shareholder in a multinational enrichment facility (MEF). Doing so would make the shareholder almost exclusively dependent upon one supplier with little possibility of benefiting from the competition of multiple suppliers.

By contrast, through a multinational fuel procurement company a new nuclear electrical company would be in a better position, if deemed appropriate, to participate in a MEF to cover a fraction of its enrichment needs.

Becoming a partner in a MEF is like getting married. Those entering such a project ought to know that getting divorced will be difficult, long, and costly.

c) Multilateral Fuel Supply Guarantees

A nuclear fuel reserve either owned by the IAEA or made available to it (e.g., the Russian model) could provide an ultimate fuel supply guarantee. Such is particularly true in cases in which a state that meets well-defined nonproliferation, safety, and security criteria (as verified by the IAEA) is denied fuel deliveries by a supplier for purely political reasons and is unable to procure substitute fuel elsewhere on the market.

If the objective of the consumer state is to minimize the risk of fuel supply disruption for purely political reasons, it will need to ensure that the supplier state provides the necessary export license in a timely manner. Fulfilling this requirement is fundamental regardless of whether the electrical utility is a shareholder of a MEF in another country.

As I previously suggested (see footnote 2), the best way for a consumer state to address the perceived risk of supply disruption is to obtain from the supplier state a binding, long-term generic export license for the LEU to be delivered under the supply contract as long as a number of specified conditions are satisfactorily met.

These conditions should include the following:

1. The recipient state has not issued a notice of withdrawal from the NPT.

2. The recipient state has concluded with the IAEA an INFCIRC/66-type safeguards agreement for the NPP under consideration. This agreement would normally be subsumed under the CSA, but would be implemented should the recipient state withdraw from the NPT so that any fresh fuel or spent fuel remaining in the recipient state would invariably be subjected to IAEA safeguards.[4]

3. The recipient state has a CSA and an Additional Protocol (AP) in force.

4. The IAEA Secretariat has drawn the conclusion, on an annual basis, that there has been no diversion of nuclear material placed under safeguards and that there are no undeclared nuclear material and activities in the recipient state.

5. The IAEA Secretariat has not raised questions or found inconsistencies concerning the recipient state's nuclear program that have not been resolved within a period of 12 months. Moreover, the IAEA Secretariat has found no indication that, in its judgment, could potentially give rise to proliferation concerns.

6. The NPP meets IAEA safety standards and an adequate level of physical protection.

The IAEA would be responsible for confirming, at the request of the supplier state, that all their conditions are fulfilled by the recipient state.

The "Russian Initiative to Establish a Reserve of Low Enriched Uranium (LEU) for the Supply of LEU to IAEA for its Member States"[5] is a good example of such a multilateral fuel supply guarantee. It is analyzed in Annex I.

The Back-End

Schematically, there are three main steps in the management of spent fuel (SF):

1. Storage after unloading at the NPP, first in a pond and then, possibly, in dry storage casks;

2. Storage at either:

    a) a centralized facility where the SF will be stored for a number of decades;

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[4] A CSA remains in force only for so long as the state remains party to the NPT, whereas under an INFCIRC/66-type agreement all nuclear material supplied or produced would remain under safeguards, even if the state withdraws from the NPT; until such time the IAEA has determined that the nuclear material is no longer subject to safeguards.

[5] IAEA, GOV/INF/2009/1, February 23, 2009, reproduced in NPT/CONF.2010/PC.III/WP.25 http://daccessdds.un.org/doc/UNDOC/GEN/N09/327/71/PDF/N0932771.pdf?OpenElement.

b) a facility close to a plant where the spent fuel will be conditioned in a form appropriate for final (geological) disposal

- either as SF in appropriate containers
- or after undergoing some mechanical treatment (e.g., cut into pieces) and encapsulation; and

c) a combined reprocessing and MOX facility, which mainly produces high-level vitrified waste (HLW), mixed U and P_U oxide (MOX) fuel elements, and some UO_2;

3. Disposal of the HLW or encapsulated SF in a geological formation.

With respect to safeguards, steps 1 and 2a are the easiest to implement. Step 2c is the most difficult.

For a country embarking on a new NPP program there are, at least in the current environment, no economic or technical incentives to opt for SF reprocessing at least during the first decade of operation.

By far the easiest and least cost-intensive solution is to store the spent fuel for as long as possible at the NPPs. This is the solution that has been implemented by most nuclear electrical utilities in the world, but it raises the concern of having SF containing plutonium in facilities scattered all over the world and potentially made vulnerable to theft, diversion, or misuse.

As is well known, SF assemblies contain plutonium that can be recovered through reprocessing and, depending on its quality, used to manufacture nuclear weapons or explosive devices. It is highly unlikely that SF under IAEA safeguards could be diverted in any significant quantity from a NPP without being detected. However, once a state has accumulated SF assemblies and mastered reprocessing it could, as the DPRK did in January 2003, withdraw from the NPT and recover the plutonium for military purposes.

Fuel Leasing

For a new nuclear electrical utility, the most attractive alternative to storing SF at the NPP would be to conclude with the supplier state an "**all-inclusive**" **fuel contract** under which the supplier would deliver fresh fuel assemblies (i.e., procure uranium, conversion, enrichment, and fabrication services) and take back the SF after an agreed-upon cooling and storage period at the NPP. For the consumer state, an all-inclusive fuel contract would have the great advantage of eliminating the problem of having to manage HLW domestically, thereby avoiding possible local opposition.

In addition, as a matter of good practice and to guarantee to the supplier state that the necessary funds will be available to cover future SF management costs, the following mechanisms would be implemented.

For each kWh produced by the NPP a specified amount of money (often expressed in USD mills per kWh or "*millage*") would have to be paid monthly into a dedicated escrow account. This would cover all transportation costs of the SF to the supplier state as well as all management, storage, conditioning, and final disposal costs of the SF assemblies incurred after their return to the supplier state.

The account would have to be managed by an appropriate international organization such as the European Bank for Reconstruction and Development (EBRD), the International Monetary Fund (IMF), or possibly the IAEA.

If the supplier state is allowed by law to retain the SF without having to return any radioactive waste to the recipient state, then the full amount of the corresponding millage would be released by the fund (with accrued interest) to the supplier state after it has re-imported the SF.

In some cases, however, the supplier may be legally obligated to include in the contract provisions whereby the recipient state would have to take back vitrified HLW or any other properly conditioned form of HLW, in a quantity (and toxicity level) equivalent to that of the fission products contained in the SF. This concept has been implemented by both France's COGEMA and British Nuclear Fuels (BNFL) for customers of their reprocessing facilities. The return of HLW would take place after an agreed-upon period of storage in the supplier state. That period could either be very short or take up to 25 years or more. In such a case, only an agreed-upon proportion of the millage would be paid to the supplier state. The remaining would be paid (with accrued interest) to the recipient state upon return of the HLW.

It is clear that the proposed fuel contract will be most attractive to the recipient state if it completely resolves its SF and HLW management problems. Such would likely be the case only in a recipient state that has not yet accumulated a large amount of SF from NPPs.

When a recipient state has already accumulated SF from any research reactor, the removal of SF by the supplier state (under agreed-upon terms) would considerably increase the attractiveness of the supply agreement. By contrast, if the supplier state were to request that the vitrified HLW be sent back to the recipient state, this attractiveness would be reduced.

An important side benefit of this scheme is to guarantee that all costs related to the back-end of the fuel cycle would be included from the start in the price of electricity produced by the NPP and not postponed (possibly for half a century or more).

Regrettably, today only Russia is in a position to offer such fully integrated services.[6]

At any rate, it would be safe and good management practice for any new consumer state to initiate an R&D program for the final disposal of SF and HLW, as soon as a decision to construct a first NPP has been taken.

Multinational SF Storage Facilities

In order not to accumulate quantities of SF containing plutonium in each and every country operating NPPs, would there be some merit to consider regional multinational SF storage facilities?

In other words, would such a facility:

- be economically advantageous?
- be better from a nonproliferation and security point of view?

To answer these questions, one should consider 3 subcases depending on whether the SF storage facility:

- is a stand-alone facility;
- is coupled with a SF conditioning facility; or
- is coupled with a SF conditioning facility located at a potential multinational SF and HLW geological disposal site.

Today, the states which have accumulated the largest quantity of SF and HLW are the US, France, Russia, Germany, Japan, South Korea, Taiwan-China, Canada, the UK, and Sweden. Among these states, Russia, France, the UK, and Japan are storing SF at their national reprocessing facilities in addition to storing SF on-site at their NPPs.

Sweden has built a stand-alone centralized storage pond 30 meters below the ground surface (the so-called CLAB is designed to provide storage capacity for 30 to 40 years before final disposal) located near the Oskarshamn NPP. Germany has constructed interim storage plants for SF in large casks at Gorleben (lower Saxony) that were eventually supposed to be disposed of on site in a deep salt geological repository, as well as at Ahaus (Nordhein-Westfalen). The German government has suspended shipments of SF casks to Gorleben and Ahaus due to intense public opposition.

If the Swedish exception can attest to the lack of attractiveness of stand-alone centralized SF storage facilities, then the construction of a regional multinational storage facility should not

[6] Russia has approved legislation allowing for the import of spent fuel (with no obligation to return HLW), although government officials have stated that Russia does not plan to import non-Russian-origin fuel. The US, on the other hand, imports spent HEU fuel, but only in small quantities and not from power reactors.

be anticipated any time soon, notwithstanding its intrinsic nonproliferation and security merits.

Constructing a new reprocessing plant cannot be economically competitive unless it has a large annual capacity (e.g., between 800 and 1000 tons of heavy metals) and guaranteed contracts with customers to fill that capacity over a long period of time (20 years or more). Reprocessing SF should not take place as long as the owner of the fuel is not in a position to recycle or otherwise sell the resulting MOX fuel (UO_2-P_UO_2).

States with significant experience with LWRs should consider the merits of burning in their reactors excess civilian (weapons-grade) plutonium, (such as the plutonium stored in the UK), or plutonium originating from dismantled nuclear warheads. In order for the resulting MOX fuel assemblies to be competitive with low-enriched fuel elements, it is likely that the owner of the excess plutonium will have to pay the electrical utility to accept and recycle it in its NPPs. In other words, the excess P_U takes on a negative economic value.[7]

The "AIMBY" and "NIMBY" Syndromes

In his opening remarks to the September 2003 General Conference of the IAEA, Director General ElBaradei noted that "considerable economic, safety, security and non-proliferation advantages may accrue from international co-operation on the construction and operation of international waste repositories." Indeed, "for many countries with small nuclear programmes for electricity generation or for research, the financial and human resource investments required for research, construction and operation of a geologic disposal facility are daunting."

Yet most national laws (except in Russia) are presently based on the principle that every country needs to store and dispose of its own nuclear waste within its national borders. The "All-In-My-Backyard" (AIMBY) principle, which is currently deemed to be politically correct, is in fact another version of the "Not-In-My-Backyard" (NIMBY) syndrome, defined as outright opposition to the importation of foreign waste for long-term storage and disposal in one's own country. This widely spread policy should be reconsidered and modified as appropriate since it is counterproductive from an economic, safety, and nonproliferation point of view.

Nonproliferation Considerations about Multinational Facilities

[7] With the possible exception of Russia, burning excess plutonium in fast reactors is not expected to be economically competitive with recycling it as MOX in LWRs in the next 20 years, but this does not mean that such reactors should not be developed.

Whether dealing with the front- or back-end of the nuclear fuel cycle, it is important to identify the characteristics of a multinational facility that would make it most valuable from a nonproliferation and security perspective.

When dealing with sensitive fuel cycle facilities such as enrichment and reprocessing plants, a first necessary condition is to have at least three partners (or shareholders), none of whom have a majority stake. A joint venture between two neighboring states with the host country holding a majority share would likely not add much benefit from a nonproliferation point of view. However, for a SF storage or disposal facility (as is the case of shared NPPs) such a condition would not be necessary.

In order not to spread sensitive enrichment technologies, multinational facilities should be established on the basis of a "black box" for shareholders who are not technology holders.[8]

As a prerequisite, the IAEA should also confirm that the six conditions mentioned on pages four and five have been met by the host country and the relevant facility. Foreign partners will have to address the sensitive issue of how to cope with cases in which the host country is either found to be in non-compliance with its safeguards obligations or withdraws from the NPT.

A "Bottom-Up" or Case-Specific Approach

Are there enrichment or reprocessing technology holders interested in establishing a multinational facility in a NNWS which does not already operate such a plant? My impression is that the true answer is no, unless there is a strong economic advantage to do so.

The German government has been encouraged by international interest in its proposed Multilateral Enrichment Sanctuary Project.[9] I doubt, however, that a technology holder like Urenco would find much commercial interest to participate in such a complex project,[10] even if the company would not likely admit this in public to avoid criticism from German authorities.

Concerning the back-end of the nuclear fuel cycle, notwithstanding the obvious economic, security, and nonproliferation merits of establishing a multinational geological SF and HLW disposal facility, unfortunately it seems that no government would likely support such a project on its territory (even if a perfect geological formation exists) as long as it has to face the NIMBY syndrome. For the reasons explained in this paper, multinational stand-alone SF storage facilities are also unlikely to be built any time soon.

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[8] Canada has so far objected that this principle be adopted by the Nuclear Suppliers Group.

[9] See IAEA INFCIRC/704, 727, and 735.

[10] Among other things, this project foresees that sensitive information and goods would have to be transported in containers assimilated to diplomatic bags, which cannot be opened or searched by the host or transit states.

South Korea

The only state that appears to be interested in constructing a new SF reprocessing plant is South Korea. The problem is that, according to the "Joint Declaration of South and North Korea on the Denuclearization of the Korean Peninsula," which entered into force on February 19, 1992, it was agreed that "*South and North Korea shall not possess nuclear reprocessing and uranium enrichment facilities*" and that "*South and North Korea shall not test, manufacture, produce, receive, possess, store, deploy or use nuclear weapons.*"

Now that North Korea has tested a nuclear device on October 9, 2006, and expelled in April 2009 IAEA inspectors tasked to monitor and verify the shut down status of Yongbyon's facilities, it is uncertain how long South Korea will continue to feel bound by the 1992 Joint Declaration.

The issue is complicated by the fact that South Korea wishes to recover nuclear material contained in SF through a process called "pyroprocessing" to create new fuel that can be used in next generation fast reactors.

Some US officials support the South Korean point of view that "*pyroprocessing is not reprocessing because it does not produce pure plutonium.*"[11] Under its current nuclear cooperation agreement with the US, which remains in force until 2014, South Korea cannot reprocess SF without first obtaining US approval. To make the project more acceptable internationally, South Korea has unofficially indicated its willingness to consider the construction of the pyroprocessing plant on its territory under a multinational arrangement. Whether such a gesture would satisfy potential proliferation concerns remains to be seen.

The case for multinational enrichment plants may be different since more states have indicated a potential interest to participate in such facilities and reserve the right to construct one domestically in the future. Among them are Canada and South Africa, the latter of which operated an enrichment facility before dismantling it after joining the NPT.

Kazakhstan has taken a 10 percent participation in the Russian International Uranium Enrichment Center (IUEC) at Angarsk. Ukraine and Armenia have indicated that they intend to take similar shares.[12] It should be stressed that the IUEC is not, as its name suggests, an enrichment plant, but rather a LEU storage facility located on the site of the Angarsk Electrolysis Chemical Complex (AECC), which operates the enrichment plant. Participants in the IUEC (where Russia will retain a majority share) will have a guaranteed access to the uranium capacity of the AECC. It is not clear why a country like Armenia – which has only one NPP[13] in operation and no large uranium resources – is interested in participating in the

[11] Miles A. Pomper, "Concerns Raised as South Korea Joins GNEP," *Arms Control Today*, January/February 2008, http://www.armscontrol.org/act/2008_01-02/gnep.
[12] South Korea and Mongolia have also reportedly expressed interest in joining the project.
[13] The Metsamor NPP is a VVER-440 Model V-230 reactor of 408 MWe, which has been in operation since 1980. Armenia envisages the future construction of a new reactor of 1000 to 1200 MWe.

IUEC, unless the venture is part of a broader commercial and financial agreement with Russia.

Two other specific cases are worth mentioning: Iran and Brazil.

Iran

There have been some indications in the past that Iran would be willing to allow the participation of foreign partners in its uranium enrichment facility at Natanz.

While the rights and obligations of foreign partners of a prospective multinational enrichment facility at Natanz have never been discussed, it is likely that Iran would retain the right to develop, produce, and install its own centrifuges in that facility without providing access to the centrifuge manufacturing workshops. Iran might welcome foreign technology holders to help in the development of more efficient centrifuges, but it is doubtful, given present circumstances, that any of them would find a commercial interest in doing so. Since the Natanz enrichment plant can in no way be commercially competitive with other such facilities, there is little economic incentive for foreign entities to become partners. The only possible motivation would be political if such a move can be seen as increasing the confidence that Iran's nuclear program is being developed exclusively for peaceful purposes.

Conversely, it is quite understandable that Iran has so far shown limited interest in becoming a partner in the International Uranium Enrichment Center at Angarsk. Iran might fear that participating in such a project would increase the international pressure for it to suspend or even abandon its domestic enrichment program. Iran has also indirectly been a shareholder[14] of the large EURODIF enrichment plant in France since the late 1970s but has never been able to obtain LEU from that facility. This highlights that the real issue at stake is the guarantee to obtain necessary export licenses not only from the state where the enrichment takes place, but also from the country where the fuel fabrication plant is located (i.e., if they are not the same).

Brazil

In Brazil, the Navy and the Nuclear Energy Commission (CNEN) began developing centrifuge enrichment technology in the early 1980s. They are operating small centrifuge cascades at the Aramar Experimental Center inaugurated in 1988. The facility is presently under IAEA safeguards, but Agency inspectors have no access inside the cascades.

More recently, Brazil has constructed the Resende Nuclear Fuel Facility, a centrifuge enrichment plant managed by Nuclear Industries of Brazil (INB) and the Brazilian Navy. The

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[14] Iran owns 49 percent of the shares of SOFIDIF, which in turn owns 20 percent of the capital of EURODIF. Iran is also a member of EURODIF's Supervisory Board (Conseil de Surveillance). The other non-French shareholders of EURODIF are Belgium, Italy, and Spain.

capacity of the facility will increase progressively and is expected, by 2015, to cover the needs of the country's two NPPs Angra 1 and 2. The enriched uranium that will be necessary to fuel Brazil's nuclear submarines will likely be produced in another enrichment facility.[15]

Brazil's enrichment program has raised concerns that it could weaken the nonproliferation regime, not least because Brazil is the only NNWS aside from Argentina to currently operate uranium enrichment facilities without having signed an AP. Reported difficulties experienced by IAEA inspectors in carrying out inspections of Brazil's enrichment facilities and the involvement of the Brazilian military establishment in the country's enrichment program only further add to concerns.

The February 2008 agreement between Argentina and Brazil to set up a bi-national uranium enrichment holding will in no way allay proliferation concerns, whereas ratifying the AP certainly would. Ratification of the AP would also lift the only remaining obstacle to the adoption by the Nuclear Suppliers Group (NSG) of a policy requiring suppliers to authorize the transfer of enrichment and reprocessing technologies only to states with an AP in force.

Conclusion

The existing commercial market for the supply of nuclear fuel is working well. Backup mechanisms similar to the Russian Initiative or reliance on a physical reserve of LEU owned by the IAEA would further improve fuel supply guarantees

Fuel leasing contracts coupled with long-term generic export licenses should also constitute a strong incentive for states starting the construction of nuclear power plants for electricity production to rely on the international fuel market, rather than on the expensive development of sensitive fuel cycle facilities domestically.

The most convincing evidence that the supply of fabricated fuel assemblies to operating NPPs will not be disrupted for political reasons can be found in UN Security Council Resolution 1737 (December 27, 2006). Indeed, although Iran does not meet the conditions required by Russia under its "Guaranteed Reserve of LEU Initiative" and is not complying with IAEA and Security Council resolutions, Resolution 1737 provides that "*all States shall take the necessary measures to prevent the supply* […] *of all items, material, equipment, goods and technology which could contribute to Iran's enrichment-related* […] *activities* […] ***except*** *the supply, sale or transfer of* […] *low enriched uranium* […] *when it is incorporated in assembled nuclear fuel elements for [light water] reactors.*"

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[15] According to Mark Hibbs: "Plans by the navy to enrich uranium for submarine reactor fuel…call for enrichment to take place at a dedicated facility…not at [the] existing Resende plant. The Resende plant…is subject to a trilateral safeguards agreement that limits the level of enrichment to 5% U-235. The reactor fuel required by the navy must be enriched to perhaps close to 10%." Mark Hibbs, "Brazil, Verification Agencies Aim for Naval Fuel Safeguards Negotiations," *Nuclear Fuel*, vol. 34, no. 5, March 9, 2009, p. 7.

Establishing SF storage and disposal facilities remain a valuable long-term objective. Truly multinational enrichment facilities located in NNWSs may also provide some nonproliferation and security benefits depending on the circumstances, but the priority should be placed on the bilateral and multilateral arrangements described above which can be implemented rapidly.

Above all, it is urgent to strengthen the IAEA's verification authority and improve the likelihood of prompt and firm UN Security Council action when a state found to be in non-compliance with its IAEA safeguards or NPT obligations does not fully cooperate with the Agency in promptly resolving any outstanding issue. Concrete steps to reach that goal have been described in a recent Carnegie Paper.[16] These steps should be implemented before the 2010 NPT Review Conference.

[16] P. Goldschmidt "Concrete Steps to Improve the Nonproliferation Regime," Carnegie Paper No. 100, April 2009, http://www.carnegieendowment.org/publications/index.cfm?fa=view&id=22943&prog=zgp&proj=znpp.

Annex I

The Russian Guaranteed Reserve of LEU Initiative

The Russian conceptual mechanism for guaranteeing "consumer states" access to a physical reserve of 120 tons of LEU in the form of UF6, as described in GOV/INF/2009/1 (February 23, 2009), is remarkable and deserves to be carefully analyzed.

The UF6 will be stored in Russia at the Angarsk International Uranium Enrichment Center (IUEC), under IAEA Safeguards, free of storage, maintenance or other costs for the IAEA. This fuel reserve will be made available to any member state of the IAEA experiencing a disruption of LEU supply, understood to be for political reasons "unrelated to technical or commercial considerations."[17]

The supply mechanism is made up of two agreements, both of which need to be approved by the IAEA Board of Governors (BoG).

The first agreement, to be concluded between Russia and the IAEA, would provide that:

- Russia undertakes to **make** the requested amount of LEU (in the form of UF6) **available** to the IAEA, and deliver the LEU to the IAEA for subsequent supply to the member state which has made the request to the IAEA; and
- Russia undertakes to issue without undue delay all the necessary authorizations and licenses for the transfer of the LEU to the IAEA and for export and supply of the LEU to the Consumer State.

The second agreement would be a supply agreement between the IAEA and the consumer state, based on a "Model Supply Agreement" (MSA) that needs to be approved by the BoG. Each supply agreement between a specific consumer state and the IAEA, based on the MSA, would also have to be approved by the Board on a case-by-case basis. The MSA would define the conditions under which the supply of LEU would take place.

The conditions Russia has mentioned are:

1. The consumer state would have to be a non-nuclear-weapon state member of the IAEA;

[17] cf. footnote 1 in GOV/INF/2007/11.

2. It must have "an **effective** Agreement with the IAEA requiring the application of safeguards on **all** its peaceful nuclear activities."

3. The IAEA has "drawn a conclusion that **all** nuclear material had been accounted for";

4. "That there was no indication of diversion of declared nuclear material."

5. "That there would not be any safeguards implementation issues concerning the State under consideration by the IAEA Board of Governors"; and

6. The consumer state would have to pay Russia the LEU delivered at the actual market spot price, so that Russia would most likely "replenish" its physical reserve of LEU available to the IAEA.

Russia makes the supply of LEU available under the above conditions without requiring the consumer state "to forgo any rights, including rights to develop a country's national fuel cycle capabilities."

Analysis

a) Based on conditions 1 and 2, the consumer state must be a member state of the IAEA with a Comprehensive Safeguard Agreement (CSA) in force. It therefore excludes nuclear-weapon states and non-NPT states.

   What is not clear is what is meant by an "effective" safeguards agreement. Does it only mean "in force"? Or does it mean something more? For example, could it mean that the IAEA is able to fully implement all the provisions of the CSA including Subsidiary Arrangements conforming to the Board's requests (e.g., Code 3.1 relating to the early provision of design information)?

b) Condition 3 implies that the consumer state has an Additional Protocol in force and that the Agency has drawn the so-called "broader conclusion." This conclusion implies that "*the Secretariat has found no indication that, in its judgment, would give rise to a possible proliferation concern.*"[18]

c) Condition 4 relates to "**indication** of diversion of **declared** nuclear material." This raises the question of what constitutes an "indication" and how this indication would be brought to the attention of the BoG before it approves the state-specific supply contract. For instance, would a cumulative quantity of Material Unaccounted For (MUF, or Inventory Difference) of more than one significant quantity constitute such an indication? This type of information is usually only reported, if at all, in vague

[18] IAEA, "Implementation of the NPT Safeguards Agreement in the Socialist People's Libyan Arab Jamahiriya," GOV/2008/39, September 12, 2008, http://www.iaea.org/Publications/Documents/Board/2008/gov2008-39.pdf.

terms in the Safeguards Implementation Report (SIR) without naming the state in question.

d) Condition 5 is perfectly relevant.

It should be made clear that if a consumer state were to call upon the Russian/IAEA LEU fuel supply guarantee the BoG, before approving the specific supply contract, would require the Director General to make a full report to the Board on all non-proliferation relevant information concerning that state.

In addition to the six Russian conditions mentioned above, the Model Supply Agreement should provide that:

a. The LEU delivered is to be used exclusively for the fabrication of fuel assemblies, which will be loaded in a specific electrical NPP;

b. All facilities where the LEU is to be used in the requesting member states are to be covered by an INFCIRC/66-type safeguards agreement concluded with the IAEA (which would meet the NSG requirement of "safeguards in perpetuity");

c. The IAEA has confirmed that all facilities (fuel fabrication plant and NPP) where the LEU is to be used meet the IAEA (and other relevant international) safety standards, and an adequate level of physical protection; and

d. The recipient state adheres to the Convention on the Physical Protection of Nuclear Material and Nuclear Facilities as amended.

One of the most difficult issues will be to determine that the disruption experienced by a member state is exclusively for political reasons "unrelated to technical or commercial considerations." Who is to make such a judgment? The IAEA has no knowledge of the commercial provisions contained in nuclear fuel contracts and it is not competent to make an authoritative judgment on whether or not these provisions have been met by either party. Under the supply contract it is likely that such a judgment can only be made by a three-judge arbitral tribunal, a procedure that can take months if not years.

Finally, Russia has stated that "*there would be no requirement for interested IAEA Member States, explicit or implicit, to forgo any rights, including rights to develop a country's national fuel cycle capabilities.*"

One should recall that in the Communication of 31 May 2006 sent to the IAEA by the Permanent Missions of France, Germany, the Netherlands, the Russian Federation, the UK and the US, it was proposed that enrichment assurances beyond the normally operating market would be provided to a receiving state which "*has chosen to obtain supplies on the international market and not to pursue sensitive fuel cycle activities.*"

It is clear that such a choice would be entirely voluntary and would in no way affect the inalienable right of any state party to the NPT to develop nuclear energy for peaceful purposes in conformity with the Treaty.

In the Russian communication to the IAEA in June 2007[19] describing the operation of the IUEC, it is stated that "*the Center is oriented chiefly to States not developing uranium enrichment capabilities on their territory.*"

Likewise, the Nuclear Threat Initiative (NTI), in a letter dated September 13, 2006, to the IAEA Director General, has offered to make a contribution to the IAEA of $50 million to help create a LEU stockpile owned by the Agency. NTI stated that "*this stockpile would be available as a last-resort fuel reserve for nations who have chosen to develop their nuclear energy based on foreign sources of fuel supply services, and therefore have no indigenous enrichment facility.*"

A recent European Commission communication on nuclear nonproliferation[20] indicated that in December 2008 the Commission decided, in principle, to support the establishment of a nuclear fuel bank under the control of the IAEA. It was understood that international fuel supply guarantees would be available to "countries willing to develop nuclear energy without having their own nuclear fuel cycle facilities."

However, apparently following the advice of Director General ElBaradei, none of the official proposals recently circulated by the IAEA concerning multilateral fuel supply arrangements are made contingent upon consumer states **choosing**[21] not to exercise their rights to enrich uranium domestically. The reason is likely to make the proposals more acceptable to all consumer states members of the IAEA. But does giving up this condition really allow the international community to better reach its nonproliferation objectives?

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[19] 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," INFCIRC/708, June 8, 2007, http://www.iaea.org/Publications/Documents/Infcircs/2007/infcirc708.pdf.

[20] COM (2009) 143 final, March 26, 2009.

[21] It should be stressed that this does not mean that the consumer state would have to renounce its **right** to develop its own fuel cycle facilities.