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Mechanisms to increase Nuclear Fuel Supply Guarantees

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1. INTRODUCTION

Almost all non-nuclear weapons states have so far relied on the international nuclear fuel supply market to fuel their electrical nuclear power plants. This is particularly true for countries that depend on nuclear energy for more than 30% of their electricity production. Indeed, international supply sustains countries that rely on nuclear power for 50% or more of their electricity.
There is not a single example in history that I am aware of where a state that had a Comprehensive Safeguards Agreement (CSA) in force had to close down an electrical nuclear power plant because it was denied the delivery of nuclear fuel.

This being said, the nuclear fuel cycle industry is an oligopoly. Many electrical utilities have not forgotten that in the 1970's there was a cartel of uranium producers and that some suppliers of enrichment services did not accept new orders or imposed highly restrictive commercial conditions.

It is imperative for any utility that has invested in nuclear power plants to have the highest assurance that nuclear fuel will be supplied at fair market prices in time to keep their plants running without interruption.

However, the fact that states with less than impeccable non-proliferation records could argue that in order to meet this objective, they need to produce low enriched uranium (LEU) domestically, 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 UF_6, it is technically in a position to produce high enriched uranium (HEU) suitable for nuclear weapons. Such material could not be produced undetected in a commercial enrichment plant (i.e. one normally limited to produce uranium with less than 5% U-235) under IAEA safeguards. But such a plant could be reconfigured rapidly to produce HEU if the state where the facility is operating withdraws from the NPT. The risk also exists that a small undeclared replicate of the enrichment facility (based on the same domestic technology) could be operated in a concealed location. The fact that both Libya and Iran have been able to work over a period of 20 years on the development

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of centrifuge enrichment without being detected by the IAEA has significantly increased the awareness of the international community that this is more than a theoretical possibility.

It is therefore urgent to develop a concept that would guarantee a highly reliable fuel supply for nuclear power reactors in non-nuclear weapons states (NNWS) while providing maximum protection against nuclear proliferation.

Fuel supply guarantees would be particularly relevant in the very rare case where a country would have been found by the IAEA to be in non-compliance with its safeguards agreement and, in order to benefit from electrical nuclear energy while reassuring the world of its peaceful use, would agree, or be required to suspend for a period of time all its nuclear fuel cycle activities.

The following describes a mechanism that could form the basis of such a proliferation-resistant guaranteed fuel supply concept.[1]

2. PROLIFERATION-RESISTANT FUEL SUPPLY AGREEMENT

A "Supplier State" and a "Recipient State" would negotiate bilaterally the terms and conditions of a fuel supply contract including its duration, the quantities of fuel involved, the pricing mechanism and the relevant fuel performance guarantees. The supply contract would have two components, one related to the supply of fresh fuel assemblies (FF) and the other dealing with spent fuel (SF) management.

2.1. Delivery of Fresh Fuel Assemblies

a. The FF would be leased to a nuclear power plant (NPP) in the Recipient State, the supplier (in the Supplier State) remaining the owner of the FF and SF at any point in time.

b. FF assemblies would be delivered in transport containers sealed by the IAEA in the Supplier State, which would remain sealed until the loading of the FF in the reactor core or their storage racks inside the reactor containment building. The number of FF assemblies stored at the NPP would not exceed at any time 2 annual reloads.

2.2. Repatriation of Spent Fuel Assemblies

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 nuclear explosive devices. It is highly unlikely that SF under IAEA safeguards could be diverted in any significant quantity from a NPP without the Agency detecting it. But, once a state has accumulated SF assemblies and masters the reprocessing technology, it could, as the DPRK did in January 2003, withdraw from the NPT and recover the plutonium for military purposes. For this reasons, and particularly for a state that has been found by the IAEA to be in non-compliance with its safeguards agreement, highly

[1] See also "The Proliferation Challenge of the Nuclear Fuel Cycle in Non-Nuclear Weapon States" by P.Goldschmidt. "Institut Français des Relations Internationales"- Paris, 26April 2004

reliable fuel supply guarantees may be linked to the assurance that SF will not be accumulated in such a state.
Therefore under the fuel supply contract, SF would have to be returned to the Supplier State after a minimum cooling time (e.g. 2 years or less if technically possible and economically justified).If not, the delivery of additional FF assemblies would be suspended.
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 mechanism would be implemented:

For each kwhe produced by the NPP a specified amount of money (often expressed in USD mills per kwhe or "millage") would have to be paid monthly into a dedicated escrow account in order to cover all transportation costs of the SF to the Supplier State and all management, storage, conditioning and final disposal costs of the SF assemblies after their return to the Supplier State.
The account would have to be managed by an appropriate international organization such as the EBRD, the 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 obliged to include in the contract provisions whereby the Recipient State would have to take back vitrified high level wastes (HLW) or any other properly conditioned form of HLW, in a quantity (and toxicity) equivalent to that of the fission products contained in the SF. This concept has been implemented by both COGEMA and BNFL for the customers of their reprocessing facilities. The return of these HLW would take place after an agreed period of storage in the Supplier State. That period could be either very short or up to 25 years or more.
In such a case only an agreed proportion of the millage would be paid to the Supplier State and the remaining (with accrued interest) to the Recipient State as and when the HLW is sent back to the Recipient State.

It is clear that the proposed fuel contract will be most attractive to the Recipient State if it resolves completely its SF and HLW management problem. This would likely be the case only in a Recipient Sate that has not yet accumulated a large amount of SF from electrical nuclear power plants.
Where a Recipient State has already accumulated SF from any research reactor, the removal by the Supplier State of such SF (under agreed upon terms) would further increase considerably the attractiveness of the supply agreement to the Recipient State. In contrast, if the Supplier State were to request that the vitrified HLW be sent back to the Recipient State, this attractiveness would likely be significantly reduced.

3. CONTRACTUAL CONDITIONS FOR FF DELIVERIES

3.1 FF deliveries would take place if and only if the Recipient State fulfils its contractual obligations and in particular:

a. SF is returned to the Supplier State within the agreed period of time;

b. The amount of assessed "millage" is paid monthly to the escrow account as required;

c. No FF or SF is removed from storage within the NPP site (and if possible from the containment building), except after the SF is loaded under IAEA surveillance immediately before its retransfer to the Supplier State in transportation casks sealed by the IAEA.

3.2. FF deliveries would be suspended in the following cases:

a. the Recipient State withdraws from the NPT.
In such a case all FF and SF owned by the Supplier State will have to be returned without delay. (cf. paragraph 4.1.a. below)

b. the Recipient State is found by the IAEA to be <u>in non compliance</u> with its safeguards agreements. FF supply would resume once the Agency has concluded that there is no undeclared nuclear material and activities in the Recipient State.

c. the IAEA has found anomalies or inconsistencies or has raised questions that have not been fully resolved within a given period not to exceed 12 months. The contract could include a provision requesting the IAEA to report any such case promptly to its Board of Governors.

4. <u>FUEL SUPPLY GUARANTEES</u>

If a Recipient State considers that it needs nuclear fuel supply assurances extending beyond usual contractual arrangements, e.g. for fear that the necessary export licences would not be granted for political reasons, the following arrangements could be considered in order to address this particular concern.

4.1. <u>Guarantee by the Supplier State.</u>

The Supplier State would grant to the Recipient State a binding long term generic export licence for all FF to be delivered under the supply contract as long as a number of conditions specified in the contract are satisfied.

These conditions could include the following:

a. The IAEA has confirmed that:

- the Recipient Sate has not issued any notice of withdrawal from the NPT
- 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 Comprehensive Safeguards Agreement (CSA), but would be implemented in case the Recipient State

withdraws from the NPT, so that any FF or SF remaining in the Recipient State would always be subject to IAEA safeguards[2].

- the Recipient Sate has a CSA and an Additional Protocol (AP) in force
- the IAEA has drawn the conclusion, at least annually, that there has been no diversion of nuclear material (NM) placed under safeguards and that there is no undeclared nuclear material and activities in the Recipient State as a whole.
- the IAEA has not raised questions or found inconsistencies or anomalies concerning the State's nuclear programme that have not been resolved within a given period not to exceed 12 months.
- the SF has been returned to the Supplier Sate within the contractual timeframe
- no FF or SF has been removed from the NPP site, except in sealed SF containers being sent back to the Supplier State
- the NPP meets international (IAEA) safety standards and an adequate level of physical protection

b. The international organization (EBRD, IMF, or IAEA) in charge of managing the escrow account has confirmed that all "millage" monthly payments have been performed in accordance with the contract.

The IAEA would not need to be a party to the contract between the Supplier State and the Recipient State, but would be required, in order for the contract to enter into force, to provide its "concurrence" that all the above conditions are included in the contract. This "concurrence" by the IAEA would be similar to the concurrence required from the Euratom Supply Agency on all nuclear fuel supply contracts concluded by EU electrical utilities. Thereafter, before each FF delivery, the IAEA (and the financial organization in charge of managing the escrow account) would have to certify that all relevant conditions have been met.

c. In the very rare cases where a State has been found by the IAEA Board of Governors to be in non-compliance with its safeguards agreement, it may well be that some exporting countries would be prepared to grant a binding long term generic export licence for FF under the conditions stated above, if and only if, in addition, the Recipient State undertakes to suspend, at least during the term of the contract, any R&D, manufacturing, construction, testing or operation activities related to the nuclear fuel cycle (except for the storage and final disposal of low, medium and high level radioactive wastes).

   The IAEA could be requested to verify that the Recipient State complies with this commitment and, if it doesn't, to report without delay to the IAEA Board of Governors.

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

4.2. Additional guarantee by the IAEA.

As foreseen in Article III.A.1 of the IAEA Statute, as a back-up to the contractual arrangement described above, the Agency could provide further fabricated fuel supply guarantees in case the FF delivery is delayed by the Supplier Sate for more than [12] months after the contractual due date for any reason other than a failure by the Recipient Sate to meet its contractual obligations and the conditions listed in paragraph 4.1. above.
In such a case the IAEA would provide substitute FF assemblies to the Recipient Sate within a period of not more than [12] months.
The IAEA would be and remain the owner of the fuel elements (whether fresh or spent fuel) and would deliver them to the Recipient Sate under terms and conditions similar to those of the original contract with the Supplier State.

The IAEA could provide this additional guarantee as follows:

4.2.1. For the delivery of fresh fuel assemblies

a) Option N°1:

The IAEA could conclude long term agreements with a number of uranium, conversion, enrichment and fuel fabrication producers whereby they would commit to reserve at all times a specified percentage of their production capacity for the IAEA. These "drawing rights" would be exercised by the IAEA if and only if the Supplier State fails to meet its contractual obligations as described above and no other substitute fuel supply is readily available.
Such an option might however be complicate to manage in practice.

b) Option N°2:

Another option, simpler to manage, would be for the IAEA to become the owner of a stockpile of low enriched UF6. This stockpile could be transferred free of charge to the IAEA for example as part of an "off market" quantity of LEU resulting from the down blending of HEU in Nuclear Weapons States (NWS) as was recently suggested by the USA[3].
The UF6 would be stored on the site of one or more uranium enrichment companies. One could consider the possibility (and evaluate the merit) of creating on the site of the relevant enrichment plants an extra-territorial storage facility belonging to the United Nations, a concept similar to that of a foreign embassy.
The IAEA would conclude contracts with those enrichment companies for the storage of the material as well as for services to adjust (e.g. within one month), as and when necessary, the enrichment of the UF6 to the desired level (below 5% U-235).
In addition, the IAEA would conclude contracts with as many relevant fuel fabrication companies as possible[4], giving the IAEA the right to request at any time the fabrication of one or more reloads of fresh fuel elements, meeting pre-

[3] Cf. INFCIRC/659 – 29 September 2005
[4] In the specific case where the fuel would be of the VVER type, the only fuel manufacturers commercially available today are located in Russia and Spain.

determined specifications, within a period of [8] months maximum after the delivery of the necessary enriched UF6 owned by the Agency.
The States where the fuel fabrication facilities are located should furthermore grant to the IAEA, under an agreement approved by the Board of Governors, a generic export licence for the fabricated FF as long as the IAEA confirms that all the conditions listed in paragraph 4.1. above have been met by the end-user. This would provide the highest possible level of fuel delivery assurance, since it is unlikely that any supplier state would not honour an agreement concluded with the IAEA.

4.2.2. For the repatriation of spent fuel.

The IAEA would need to take the SF back from the Recipient Sate within the contractual timeframe.
For the time being, Russia is the only country that accepts, for LWRS, the repatriation of SF of Russian origin without having to send back HLW to the country that has used the fuel for electricity production.
Ideally, Russia could also agree to take back (at the contractual "millage" rate) SF belonging to the IAEA in the very unlikely event that this would be necessary. Other state may follow that example. In this regard it should be noted that the US is already repatriating spent HEU fuel of US origin used in foreign research reactors. The US should consider extending this policy to spent fuel owned by the IAEA in the very unlikely event considered here.

Other NWS should also undertake to take over SF owned by the IAEA if this were ever to be necessary, since such a situation would only occur in order to resolve a major nuclear proliferation concern, especially if it is in relation to a state that has been found in non-compliance and has agreed to suspend all fuel cycle related activities.

If the IAEA ever becomes the owner of SF, as a consequence of the fuel supply mechanism described above, it will need to have the guarantee that, at least one state will commit to take over the ownership of the SF for further storage, processing and final disposal. Without such assurance it is unlikely that the IAEA Board of Governors would agree to provide the fuel supply guarantees described in this paper.

5. CONCLUSION

It should be expected that, as in the past, almost all electrical utilities will be comfortable to relying on normal commercial practices to acquire the fuel required for their nuclear power plants, and will be wary of the involvement of any governmental or international organization. In some exceptional cases, a utility or a state may feel the need for increased fuel supply guarantees in order to be protected against the risk of fuel supply disruption for political reasons.
The mechanism developed in this paper should simultaneously provide this additional guarantee and maximum protection against nuclear proliferation.

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Addendum

The following clarifications are provided in response to questions that were raised with the author following this paper's release on November 8, 2005.

Delivery of FF assemblies (§2.1)

1. The question was raised whether by "leasing" the FF assemblies there was an implication that payment would be made over the "lease" term. The answer is, no, there would be an up-front payment for the total cost of the assemblies at the time of delivery.

2. The question was raised as to why the number of FF assemblies stored at the NPP would not exceed 2 annual reloads.
   The 2-year limit is suggested based on cost and practical considerations such as the need to adjust fuel enrichment levels over time. Proliferation concerns would not increase significantly if a Recipient State chose to maintain a larger reserve, provided the reserve remains under IAEA safeguards.

Additional guarantees by the IAEA (§4.2)

3. The question was raised as to the necessity for the Recipient State to wait 12 months before calling upon the IAEA back-up supply. It would **not** be necessary for the Recipient State to wait for any particular period once it becomes clear that FF delivery will be delayed by the Supplier State for any reason other than a failure by the Recipient State to meet its contractual obligations and the conditions listed in Section 4.1. In such case the Recipient State would inform the IAEA and request it to activate its fuel supply guarantee.
   Since it would take around 12 months for the IAEA to be in a position to deliver substitute FF assemblies, this period of time should be used to try to resolve the issue with the original supplier and to find out whether any other substitute fuel supply would be readily available.
   If the Recipient State has a reserve of FF assemblies sufficient to cover the operational needs of the NPP for at least two years, it would allow the IAEA back-up mechanism to be effectively implemented in time to guarantee the continuous operation of the electrical plant.

Magnitude of IAEA back-up fuel inventory

4. The question was raised as to how large the IAEA's back-up fuel inventory would have to be.

   It is unlikely that many utilities already operating electrical nuclear power plants for some years would feel the need to seek fuel supply guarantees other than diversifying as much as possible their sources of supply, concluding flexible fuel supply contracts and managing appropriate nuclear fuel inventories.

The fuel supply guarantee suggested in this paper could however be attractive for those states that, for any reason, feel that they do not have access to reliable and diversified sources of supply. The proposed mechanism would be most relevant in the very rare case where a country has been found by the IAEA to be in non-compliance with its safeguards agreement (i.e. Iraq, DPRK, Libya and Iran) and, in order to benefit from electrical nuclear energy while reassuring the world of the exclusively peaceful use of its nuclear programme, such country would agree, or be required, to temporarily suspend all its nuclear fuel cycle activities.
So far none of these states have a large scale commercial electrical nuclear power plant (NPP) in operation. The first and most urgent case to be considered is the VVER-1000 MWe at Busher, whose sole fuel supplier today is Russia. In this specific case, since the only VVER fuel manufacturing plant outside Russia is located in the European Union, the IAEA back-up low enriched UF6 stockpile should logically be stored on the site of one of the European commercial enrichment facilities.
In this case an initial inventory equivalent to one reload (approximately 30 t UF6 at 4% U-235) should be sufficient, considering the fact that as soon as this material would be used, the amount of money received should allow the IAEA to promptly buy a replacement quantity.
In a more global perspective, the IAEA would ideally store some of its back-up fuel inventory in all regions of the world possessing commercial enrichment plants: China, the European Union, Japan, Russia and the United States.
It is, however, recommended that implementation and testing of the proposed mechanism start on a modest scale, by addressing first the immediate need described above.

<u>What about funding?</u>

5. The question was raised as to what the financial implications of the proposed mechanism would be for the IAEA.

   The low enriched UF6 stockpile to be owned by the IAEA (initially equivalent to one annual reload or abut 30 tonnes of low enriched UF6 at a cost of around $ 25 million) should be “given” to the IAEA as suggested in Section 4.2.1.b, or the IAEA should be provided with the extra-budgetary resources necessary to buy the material.
   If a Recipient State calls upon the IAEA to deliver FF assemblies it would have to pay the IAEA the price fixed under the initial contract with the supplier. Depending on the evolution of the nuclear fuel market and the contractual pricing formula, this amount may be higher or lower than that necessary for the IAEA to fully reconstitute its stockpile.
   If it is less, then the IAEA should be provided with the additional extra-budgetary funds necessary. The possibility of establishing a special contingency fund for that purpose could be considered.