WNA Report

Ensuring Security of Supply in the International Nuclear Fuel Cycle

World Nuclear Association

Introduction

In August 2005, the WNA established a Working Group to consider the Security of Supply in the International Nuclear Fuel Cycle. This Working Group issued their report on 12 May 2006.

Since that report was issued, there have been many further presentations and discussions at the IAEA and from a number of individual National Governments.

The WNA Working Group has continued to meet and review the newly proposed initiatives in this field and it is now appropriate to update the conclusions of the Group. Although in general the original conclusions remain valid, there are some revisions to the WNA considerations, and it is worthwhile to include a summary of all the initiatives which have been put in place/proposed since 2006.

In the 2006 report, it was considered that a necessary pre-requisite to offering strengthened assurances of supply was that the prospective customer would have to volunteer to forgo its rights to develop or install and operate its own enrichment or reprocessing technology. Whilst this seemed at that time a key element, it has become clear in discussions with countries that currently do not have nuclear power plants but are considering a nuclear power strategy, that this would be a major barrier to their strategic considerations. It gave the view that the small number of existing technology holders were attempting to sustain a monopoly situation which, rather than adding to the feeling of security of supply, was having the opposite impact, and driving a strategic approach which included the need to develop fuel cycle technologies, in case the existing market players abused their monopoly situation in the future.

The WNA conclusions have therefore been modified, both to remove this pre-requisite, and to look further into the future as nuclear capacity has expanded, and to consider the approach to multi-national, regional fuel cycle centres as soon as the regional demand is large enough to justify this.

This report updates the May 2006 report, and as an appendix, provides a summary of the main additional initiatives aimed at increasing the security of supply considerations (eg the IAEA Fuel Bank and others).

General Findings

The Working Group recognised and welcomed the objective of avoiding the spread of sensitive technologies and facilities through a credible assurance of access to enrichment and reprocessing/recycling services and, in the longer term, through the establishment of multilateral nuclear fuel cycle centres. Achieving this objective means ensuring that any State embarking on a programme of building nuclear power plants should be able to obtain a reliable guarantee of attractively affordable supply through existing market players.

Any action in fulfillment of such a guarantee would, of course, depend on the State being in full compliance with all international safeguards requirements, as determined and verified by the IAEA.

Customer Perspectives

The Sub-Group on Customer Perspectives brought together views from within the WNA membership as to how existing customers perceive the security of current supply arrangements, and considered how these might be strengthened.

The Sub-Group noted from the outset that existing world market arrangements offer a very high standard of security of supply in all aspects of the nuclear fuel industry. Indeed, in the history of the industry, there has never been a disruption of supply that has led to a loss of electricity generation. Several instances of major discontinuities in recent years have all been resolved with conventional market mechanisms.

The effectiveness of market mechanisms is enhanced by the common practice of utilities in following strategies that incorporate inventory, diversity of supply and contractual flexibilities which are exercisable in the event of supply disruptions.

The current IAEA and Euratom safeguards regimes are effective and deserve a higher public profile. It is essential to nuclear commerce that customers be in full compliance with these safeguards regimes, and a more clear-cut penalty system for non-compliance should be agreed internationally at inter-governmental level.

Any approach to strengthening security of supply should be consistent with the continued effective operation of the competitive world market. Moreover, any arrangements for emergency or back-up or guarantee supply arrangements should be used only as a last resort if existing market arrangements have failed, and not as a substitute for market supplies. Similarly, there should be no price discrimination against supplies from the normal market, and hence no price subsidies for the emergency or back-up or guarantee supply arrangements.

The triggering of emergency or back-up or guarantee supply arrangements should occur only in the event of a political disruption of the normal market for a reason other than a non-proliferation issue. Such triggering should not result from a technical or economic disruption. Experience has shown that any technical or economic disruption can be dealt with by normal operation of the existing world market, and this should continue to hold true.

As a final back-up, there have been a number of helpful proposals such as the IAEA Fuel Bank, the Russian Fuel Bank and the UK Enrichment Bond concept, and these would bring an additional level of security of supply, without removing large quantities of material from the normal supply process. Any such stockpile material would, of course, need to be controlled by a widely accepted international body, and we would envisage the IAEA in this role. It will be vital that the release of this material is done in such a way that it does not have an impact on the normal operation of the existing market (either in pricing or other contractual terms).

Front-End Views

To supplement existing market mechanisms in enrichment services, a reinforced guarantee of supply for enrichment services should be established through a joint commitment by existing uranium enrichment companies ("enrichers") supported by the IAEA and national governments.

This proposed supply assurance concept would be a guarantee-in-depth analogous to defence-in-depth in reactor safety. It would consist of three layers of guarantees:

- Level I: Basic supply security provided by the existing world market.
- Level II: Collective guarantees by enrichers supported by governmental and IAEA commitments.
- Level III: Government stocks of enriched uranium product (EUP).

The initial level of guarantee, from the existing world enrichment market (Level I), is based on the strong multi-year performance record of the international SWU market.

The second level of guarantee (Level II) would be invoked in the event of a disruption of normal commercial supplies for bilateral political reasons between an enricher and a customer State.

Level III – Government EUP Stocks – would be used as a last resort in the unlikely event that enrichers could not meet their backup supply commitments as embodied in Level II.

This multi-level guarantee mechanism would operate in case of a contract suspension for political reasons. Upon notification by the concerned enricher or customer, the IAEA would determine the customer's legitimacy in light of pre-defined criteria pertaining to its compliance with safeguards requirements and the events leading to the contract suspension. The Agency would thereupon notify the other (remaining) enrichers to implement their obligations.

Under the Level II backup supply arrangements, the other enrichers would at this point be committed to supply. To ensure that no single enricher is unfairly burdened with the responsibility of providing backup supply, the other enrichers would supply the contracted enrichment in equal shares under terms previously specified between the IAEA and the enrichers. (A standard backup supply clause would be included in commercial contracts between enrichers and customers eligible for such backup.)

Designing a similar mechanism for fuel fabrication would be more complex. Because fuel design is specific to each reactor design, an effective mechanism would require stockpiling of different fuel types/designs. The cost of such a mechanism could thus be substantial. (It should be noted that uranium fuel fabrication per se does not present a proliferation risk.)

Back-End Views

Current declared recycling strategies do not, in the short term, necessitate new reprocessing facilities for fuel from light water reactors. Thus, existing reprocessing/recycling capacities are sufficient to meet foreseeable demand. Any State that does not produce an annual used fuel discharge sufficient to justify its own national reprocessing/recycling facility should be able to obtain adequate guarantees of supply through existing market players.

In future, however, a situation might arise in which a significant number of States, anticipating a large expansion in their use of nuclear power, choose a recycling strategy to ensure the sustainable long-term management of their resources. This could lead to a call for increased capacities in existing facilities or new builds.

In light of the robust nuclear energy initiatives now underway in many countries, concepts of international reprocessing/recycling centres are worth pursuing and deserve further, more detailed review. Effectively implemented, probably on a regional basis, such a concept could enhance guaranteed access to recycling services for countries wishing to close their fuel cycle.

To limit the spread of such technologies worldwide, countries already possessing these technologies should be encouraged to offer their services to meet such demand. The goal should be to achieve a situation in which countries without back-end fuel cycle facilities have a clear-cut option of having their spent fuel reprocessed and MOX fuel manufactured, at affordable prices, at national or multinational back-end facilities located in countries with expertise and a high level of industrial development in this area. Establishing such arrangements would require the negotiation of inter-governmental agreements.

It should be noted that, whilst subsequent waste treatment, storage and disposal could also become a security of supply consideration for new nuclear power operators, this is not reviewed in this report. This may become a topic for future consideration.

Longer Term Considerations

Whilst we are strongly recommending to any country considering nuclear power as an option to employ the strategic approach of relying on the existing world market for enrichment and reprocessing, particularly with these three levels of guarantee in place, and we firmly believe that whilst the demand is small, the economics of going to the existing market will always be much better than trying to start-up new, small capacity facilities. However, there will come a point where local or regional demand makes a regional fuel cycle centre a reasonable option, from logistical and economic points of view.

The trigger for such a regional approach may come from any one of, or even a combination of, strategic considerations - economics from the scale of regional demand - logistics - or others. Once it does become a consideration in any region, we would encourage a multi-national fuel cycle centre approach, with existing technology holders supplying the technology on a “black-box” basis. This gives the security of having a source of supply in the region without new countries feeling the need to develop their own technology.

This approach still carries proliferation risks, in that such regional centres could be "nationalised" and reconfigured to produce weapons grade materials, but this would be clearly evident, as it would require the breaking of international agreements and refusal for entry to the IAEA Safeguards Inspectors. We strongly recommend that consideration be given to the development of more proliferation-resistant technology to reduce this technology risk in the longer term.

Conclusions

The current world market provides a considerable degree of security of supply, and has never to date failed to ensure continued operation of nuclear energy generation worldwide.

Starting from this premise, the industry recognizes that there are ways to strengthen security of supply through the provision of explicit guarantees that would be implemented by the IAEA under provisions established by multilateral agreement.

The nuclear industry recognises and accepts the responsibility to work with governments and the IAEA to achieve the aim of increased security of supply on the foundation of a well-established and successfully functioning world market.

Appendices:

1. Working Group Membership and Terms of Reference
2. Views of the Customer Perspectives Sub-group
3. The Concept of Security of Enrichment Supply
4. Back-End Multilateral Nuclear Approaches: The Industry's Non-Proliferation Viewpoint
5. Excerpt from 'Multilateralization of the Nuclear Fuel Cycle: Helping to Fulfill the NPT Grand Bargain', Yuri Yudin

September 2011

Appendix 1
SECURITY OF THE INTERNATIONAL NUCLEAR FUEL CYCLE WG

WG Membership 2012

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Terms of Reference

The WNA Board agreed at its meeting on 12 April 2005 to establish a Working Group to monitor, report on developments, and guide WNA contributions to the evolving policy debate on the security of the international nuclear fuel cycle.

In establishing the Working Group, the Board took note of recent proposals, emanating primarily from the IAEA, aimed at enhancing nuclear security and strengthening the non-proliferation regime. These proposals relate to uranium enrichment, reprocessing of spent nuclear fuel, and storage and disposal of spent nuclear fuel. These proposals have potentially significant implications for the nuclear industry, both commercially and in terms of public perception.

It is in the interest of a sound public debate that the nuclear industry contribute its unique analysis and perspective, born of decades of operational experience. By assembling practical knowledge and expertise in this area, the WG can formulate, and guide the WNA in expressing, an industry viewpoint that brings valuable realism to the analysis of future public policy options.

The Security of the International Nuclear Fuel Cycle WG will:

- Monitor and assess developments within its remit.
- Seek to develop a coordinated industry view as to how nuclear security and non-proliferation objectives can best be implemented in a manner consistent with commercial realities in an expanding global industry.
- Make recommendations on actions that should be taken or facilitated by the WNA.

The Working Group will support and guide WNA engagement with the IAEA to ensure that the industry's analysis contributes effectively to the consideration of future policy options.

Appendix 2
Views of the Customer Perspectives Sub-group

The Track Record

The uranics and nuclear fuel fabrication industries have historically maintained high standards of security of supply. Indeed, since the introduction of nuclear power there has never been a disruption to supply which has led to a loss of electricity generation. Moreover, nuclear fuel is easy to stockpile at licensed facilities, and there are many other mechanisms embodied in the market which promote security of supply.

The strength and flexibility of the existing supply system has been demonstrated in recent years by four major discontinuities: hex conversion supply disruptions, a fire at a major Australian producer's plant, a flood at a major mine in Canada, and adverse weather conditions which impacted on export of Russian supplies. All these have been resolved by the use of conventional market mechanisms.

Existing Measures to Promote Supply Security

It is well established practice that utilities maintain stocks of finished fuel and intermediate products down the manufacturing chain to natural uranium, while suppliers also maintain stockpiles to cover risks of supply disruption. Such stockpiling is facilitated by the low cost of nuclear fuel in relation to the costs of electricity generation and by the relatively small physical volumes involved.

Most utilities follow strategies that incorporate diversity of supply and rolling procurement programmes. These strategies emphasize working with suppliers with good credentials and a track record of high reliability. In addition, many supply contracts provide flexibilities that can be exercised in the event of supply disruptions.

Key Objectives of Any New Security of Supply Initiative

Any new arrangements should be based on the strengths of the existing arrangements that provide supply security and use international safeguards to prevent diversion of materials. Any new mechanisms should be targeted, e.g. on new market entrants. Emergency arrangements should be deployed as a last resort and not as a substitute for market mechanisms. The need for such arrangements should be subject to periodic review.

New arrangements should be designed to minimize the impact on normal commercial mechanisms, and any stockpiles or guarantees established should not remove material from the normal supply process. Equally, such mechanisms should be used as a backup to existing supply, and not as a replacement. Finally, there should be no price discrimination against supplies from normal market mechanisms, i.e. the arrangements should not involve price subsidies. The use of material previously employed in the military cycle would minimize disruptions to conventional market mechanisms; former military HEU stocks would be a suitable vehicle for providing such assurance.

Access to New Security Arrangements

Criteria for the receipt of emergency supplies should be defined and formalized in advance. They should be triggered by a failure of normal commercial supply for an end user with a verified commitment to nuclear non-proliferation. The most likely reasons for supply disruptions will be political rather than technical, and control of emergency stockpiles should therefore be placed with an independent international body, presumably the IAEA. The mechanism for emergency stockpiles should be transparent and market-neutral.

Measures to Strengthen Public Confidence in the Existing International Safeguards Regime

There has never been a diversion of materials from nuclear reactors that are under IAEA safeguards, and the effectiveness of existing IAEA/Euratom safeguards regimes should be given higher public profile. Universal ratification of the Additional Protocol to traditional IAEA safeguards agreements would strengthen public confidence. A more clear-cut penalty system for non-compliance should be agreed internationally at an inter-governmental level.

Conclusions

- Full NPT compliance must be a prerequisite for access to supply.
- Existing market mechanisms have been proven to work well in dealing with supply disruptions.
- New approaches to addressing security issues should be consistent with continued successful operation of the competitive market.
- The criteria for access to the guarantee mechanism should be defined in advance.
- Emergency supply arrangements should be used as a last resort and not as a substitute for market supplies.
- The use of former weapons HEU would lessen the impact on the market.

Appendix 3
The Concept of Security of Enrichment Supply

Introduction

To address concerns relating to security of supply, a guarantee of supply of enrichment services should be established through a joint commitment by existing uranium enrichment companies ("enrichers") in an IAEA-supported mechanism established by multilateral agreements.

This supply assurance concept would be a guarantee-in-depth analogous to defence-in-depth in reactor safety. It would consist of three layers of guarantees:

- Level I: Basic supply security provided by the existing world market.
- Level II: Collective guarantees by enrichers supported by governmental and IAEA commitments.
- Level III: Government stocks of enriched uranium product (EUP).

The initial level of guarantee, from the existing world enrichment market (Level I), is based on the strong multi-year performance record of the international SWU market.

The second level of guarantee (Level II) would be invoked in the event of a disruption of normal commercial supplies for bilateral political reasons between an enricher and a customer State.

Level III – Government EUP Stocks – would be used as a last resort in the unlikely event that enrichers could not meet their backup supply commitments as embodied in Level II.

The guarantee-in-depth approach is illustrated in Figure 1.

This paper deals exclusively with the guarantees of the enrichers (Level II).

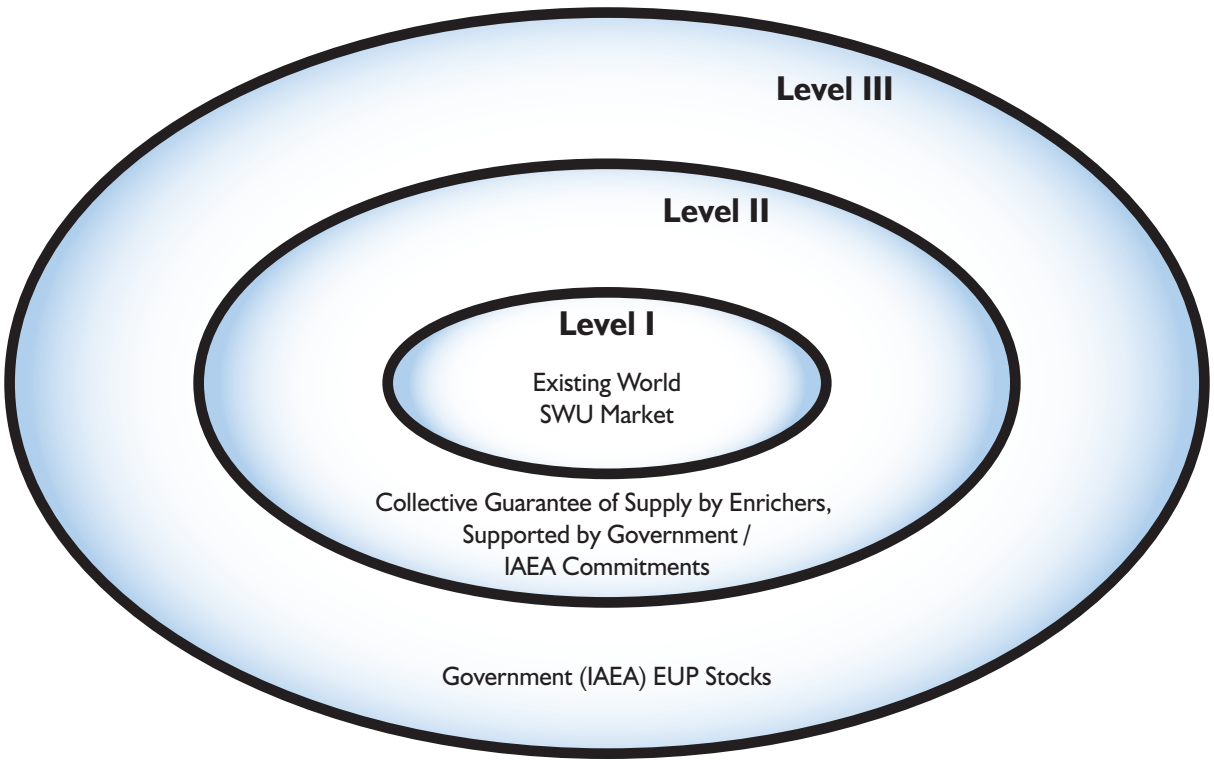

Figure 1: Multi-Layered and Multi-Lateral Guarantee of Supply

A Multilateral Approach by Existing Enrichers to a Guarantee of Supply (Level II)

The guarantee mechanism must have a number of essential characteristics:

- To be eligible, a customer State must have made a commitment to forego the development of, or the building or operation of, enrichment facilities.
- The IAEA must certify that the customer (and the host nation) are, and are expected to remain, in full compliance with international safeguards.
- The enrichers must be compensated for the cost of providing the Level II guarantee (e.g., dedication of inventory, construction of facilities, and actual supply necessary to fulfil this commitment).
- The basic commercial contract must have been suspended for political reasons not related to non-proliferation issues. Commercial issues or capacity planning problems at the supplier would not trigger the Level II guarantee.
- The mechanism must be market neutral and must not modify normal commercial market practices in enrichment. Contracts would continue to be negotiated on an individual and confidential basis, but would include a commonly agreed standard clause providing where it would apply (see below).

As stated above, the mechanism would apply in the case of a contract suspension for political reasons. The IAEA would intervene, following notification by the concerned enricher or customer. It would determine the customer's eligibility in light of its and its country's compliance with the above mentioned conditions, certify that the events leading to the contract suspension had met pre-defined criteria for invoking the supply assurance, and then notify the other (remaining) enrichers that their commitment to implement the Level II backup supply had been triggered.

A standard backup supply clause would be included in the base commercial contracts between enrichers and customers eligible for such backup. To ensure that no single enricher is unfairly burdened with the responsibility of providing backup supply, the other (remaining) enrichers would then supply the contracted enrichment in equal shares under terms specified between the IAEA and the enrichers.

To ensure proper execution of the supply guarantee, an international framework would be required:

- All IAEA members would be committed not to initiate commercial or financial retaliation measures against the interests of the enrichment suppliers if and when the IAEA had triggered the implementation of the Level II guaranteed supply.
- The IAEA would be assigned the responsibility to determine the eligibility of customers and to trigger implementation of the guarantee.
- Enrichment supplier countries should undertake a formal commitment to allow the export of enriched uranium to countries in compliance with the above commitments, if and when the IAEA had triggered the implementation of this Level II guaranteed supply.
- Enrichers would be compensated for the costs associated with providing the supply assurance.

Once agreed, the multilateral mechanism would be defined and formalized in an IAEA Information Circular (INFCIRC). Each enricher would agree to terms with the IAEA following confirmation from its home government that the back up arrangement is consistent with applicable laws and regulations.

Appendix 4
Back-End Multilateral Nuclear Approaches: The Industry's Non-Proliferation Viewpoint

The imminent worldwide expansion of the civil nuclear industry can be expected to lead to an increasing number of States seeking assurances of supply in materials, services and technologies. In anticipation of this, different ideas have recently emerged as to how these demands could be met on a global scale while further reducing potential proliferation risks.

One such idea is that of Multilateral Nuclear Approaches, or MNAs, as presented in the IAEA's Expert Group report (INFCIRC/640) in February 2005. The options proposed therein fall into three general categories: assurances of services not involving facility ownership, conversion of existing national facilities to multinational facilities, and construction of new joint facilities.

The present text details the industry's position concerning the non-proliferation aspects of MNAs in the back-end of the fuel cycle; that is, reprocessing and recycling of spent fuel, and final waste disposal.

Reprocessing and recycling

As stated in INFCIRC/640, many of the existing reprocessing and recycling facilities are essentially State-owned, implying that any assurance of service from a supplier would be based on the implicit or explicit agreement of the corresponding government. A choice of suppliers of reprocessing services is also important to potential user countries. Current declared recycling strategies worldwide do not require the creation of new reprocessing facilities (national or multinational) for spent fuel from light water reactors in the short term. However, a State anticipating a significant expansion in its use of nuclear power in the near future may well choose a reprocessing-recycling strategy in order to ensure a sustainable long-term management of its resources, including the optimization of its ultimate waste management. Although it may be argued that under certain economic conditions a once-through fuel cycle is attractive, particularly if there are no plans for long-term nuclear developments, the constant growth of uranium prices on the world market and the current excess of demand over supply, as well a resource conservation arguments, may favour the choice of a closed cycle.

Reprocessing, MOX fuel fabrication, and recycling of MOX fuel in a reactor performed in a timely manner with appropriate safeguards can actually decrease the quality and quantity of plutonium and offer an upgrade of the spent fuel standard, while minimizing the risk of diversion of fissile material. A State that has entered into comprehensive safeguards agreements with the IAEA (in the case of non-nuclear weapon States), that wishes to pursue a reprocessing-recycling strategy, and that possesses a sufficiently large nuclear fleet, should thus not be prohibited from acquiring its own reprocessing and recycling facility. On the other hand, the spread of such technologies worldwide should be avoided in order to limit the risks of diversion of the technology for non-peaceful purposes. Therefore, countries already possessing these technologies and officially pursuing the strategy of a closed nuclear fuel cycle should offer their services in reprocessing and MOX-fuel fabrication to other States, giving them the opportunity to resolve the issue of spent fuel management and to transfer MOX fuel under appropriate safeguards. Should a State not wish to reuse its separated fissile materials as MOX fuel, the timely use of the MOX fuel by a utility in a third party with appropriate non-proliferation credentials should be encouraged. In default of such a possibility, the fissile material could be immobilized as final waste.

Final waste disposal

If, for a given State, spent fuel is considered as a final waste form to be disposed of, then the existence of regional or international repositories must be favoured from a global non-proliferation viewpoint in order to limit in the long-term the dissemination of "plutonium mines", and to reduce and optimize international safeguards resources.

On the other hand, waste immobilized via vitrification following reprocessing does not pose any risk of proliferation, although close control by the national authorities of the highly radioactive waste will still be necessary for security reasons. Since a repository for vitrified wastes does not require safeguards by the IAEA standards, it may be feasible to implement such a facility in any State possessing a suitable geological site and industrial facilities. The development of international waste repositories

not requiring safeguards (i.e. specifically for vitrified HLW) could be an incentive for certain countries to choose reprocessing if associated services for waste disposal were offered. In this case, this should be proposed on a non-discriminatory basis, again irrespective of the country of origin of the fuel vendor.

Fuel leasing/take-back options

A leasing/take-back approach should also be envisaged for any country that uses or wishes to use nuclear power, but may not be in a position to implement safe and secure disposal. This approach could even be proposed on a wider basis once a final repository for ultimate waste exists on an international and non-discriminatory basis. However, while there may exist a few States prepared to host an international repository, this is politically very complex and will probably prove feasible only after a number of national repositories are fully operational.

Moreover, a take-back policy obliging the supplier country to dispose of the final vitrified waste after reprocessing would not be justified, as explained earlier, from a non-proliferation standpoint.

In summary, the concerns and objectives of the industry in relation to multilateral approaches to the back-end of the fuel cycle are:

- To offer a range of viable solutions for the management of spent fuel and waste. Should a State choose to reprocess its spent fuel, a guarantee of access to reprocessing and waste management services should be secured, provided that the route foreseen for the subsequent management of the separated fissile material is appropriate from a non-proliferation viewpoint.
- To encourage States with already existing back-end facilities to service foreign regional customers (under long-term contracts or with appropriate capital shareholding) to avoid the spread of sensitive nuclear technologies worldwide. From the non-proliferation perspective, the establishment of multilateral nuclear fuel cycle centres operating under full IAEA safeguards is considered to be a promising long-term approach.
- To encourage competition within a multilateral nuclear approach. If political or technical barriers prevent a State disposing of its own final waste, a genuinely international and non-discriminatory solution should be available.
- To encourage national efforts and international collaboration on the research and development of advanced nuclear reactor and fuel cycle reprocessing technologies that further increases proliferation resistance (for instance by not separating plutonium) and minimizing the waste to be ultimately disposed of.
- To support pragmatic approaches. Promoting ideal but politically infeasible solutions may only postpone decisions that are needed to afford predictability in an industry where rapid and effective development is needed to meet human and environmental needs.

Appendix 5
Excerpt from 'Multilateralization of the Nuclear Fuel Cycle: Helping to Fulfill the NPT Grand Bargain', Yuri Yudin

Existing Proposal for Multilateral Approaches

Over the past few years, states, the nuclear industry, and international organizations have put forward a number of proposals regarding multilateral approaches to the nuclear fuel cycle and assurances of nuclear fuel supply.[1] These proposals differ considerably in their vision, scope, targets, and implementation timelines. As an acknowledgement of current political realities, many of them entail virtually no multilateralization beyond seeking to provide extra assurances of reactor fuel supply to offer states attractive alternatives to going into potentially risky and costly business of acquiring their own enrichment capacities. These proposals are designed as "guarantees-in-depth" or supplement instruments for the existing nuclear market. As such, they would only be triggered in the event of a disruption in normal commercial supplies caused by factors unrelated to technical or commercial considerations. The proposed supplemental instruments can be categorized into two groups: assurance of supply proposals and fuel bank proposals.

Assurance of supply proposals:

- **World Nuclear Association Proposal** (May 2006). A World Nuclear Association (WNA) Working Group on Security of the International Nuclear Fuel Cycle proposed a three-level mechanism to assure the supply of uranium enrichment services: (a) basic supply security provided by the existing world nuclear market mechanisms, (b) collective guarantees by enrichment companies supported by commitments from governments and the IAEA, and (c) government stocks of enriched uranium product.[2] The second level would be triggered only in the event of a disruption of normal commercial supplies. If one enricher could not meet its contractual obligations due to political pressure from its government, then all enrichers party to the agreement would fill the gap from their own resources under terms specified between the IAEA and the enrichers. This guarantee would be given to all consumer countries contracting to obtain enrichment services from any enricher party to the agreement. If that network then failed, the third tier of supply assurance, represented by stocks of enriched uranium product held by national governments, could be used as a last resort.
- **Six-Country Concept** (June 2006). The six enrichment service supplier states – France, Germany, the Netherlands, the Russian Federation, the United Kingdom and the United States of America – proposed a modified version of the WNA proposal, which essentially offers two levels of enrichment assurance beyond the normally operating market.[3] At the "basic assurances" level, suppliers of enriched uranium would agree to substitute for each other in the case of certain supply interruptions to customer states that have "chosen to obtain suppliers on the international market and not to pursue sensitive fuel cycle activities". At the "reserves" level, participating governments could provide physical or virtual reserves of LEU that would be made available if the "basic assurances" were to fail. Rights regarding the use of these LEU reserves could formally be transferred to the IAEA to provide greater assurance of supply.
- **IAEA Standby Arrangements System** (September 2006). Japan proposed the establishment of an information system (database) as a compliment to the Six-Country Concept to help prevent interruptions in nuclear fuel supplies.[4] The system, to be administered by the IAEA, would disseminate information contributed voluntarily by IAEA member states on their national capacities for uranium ore, uranium reserves, uranium conversion, uranium enrichment and fuel fabrication. Should disruption occur, the IAEA would then act as an intermediary between consumer countries and countries that could provide the required services or materials.
- **UK Nuclear Fuel Assurance Proposal** (September 2006). The United Kingdom proposed a so-called "bonding" principle that would—in the event that the IAEA determines that specified conditions have been met—guarantee that national enrichment providers would not be prevented from supplying enrichment services, and provide prior consent for export assurances.[5] A formal agreement between governments, to be overseen by the IAEA, would ensure that suppliers are not unduly withheld for non-commercial reasons from fulfilling their contractual obligations.

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[1] For details and discussion of the main proposals, see Yury Yudin, Multilateralization of the Nuclear Fuel Cycle: Assessing the Existing Proposals, UNIDIR, 2009, and Yury Yudin, Multilateralization of the Nuclear Fuel Cycle: The Need to Build Trust, UNIDIR, 2010.

[2] "Ensuring Security of Supply in the International Nuclear Fuel Cycle", World Nuclear Association, 2006.

[3] IAEA, Communication dated 31 May 2006 received from the Permanent Missions of France, Germany, the Netherlands, the Russian Federation, the United Kingdom of Great Britain and Northern Ireland and the United States of America, document GOV/INF/2006/10, 1 June 2006.

[4] IAEA, Communication received on 12 September 2006 from the Permanent Mission of Japan to the Agency concerning arrangements for the assurance of nuclear fuel supply, document INFCIRC/683, 15 September 2006.

[5] IAEA, Communication received on 12 September 2006 from the Permanent Mission of Japan to the Agency concerning arrangements for the assurance of nuclear fuel supply, document INFCIRC/683, 15 September 2006.

Fuel bank proposals:

- **US Proposal on a Reserve of Nuclear Fuel** (September 2005). The United States announced that it would commit up to 17 metric tons of HEU deemed in excess of national security needs to be down-blended to LEU to use as a reserve "to support assurances of reliable fuel supplies for states that forego enrichment and reprocessing".[6] The material would remain under US control and subject to obligations attached to US-origin nuclear material.
- **IAEA Nuclear Fuel Bank Proposal** (September 2006). The Nuclear Threat Initiative (NTI) offered to contribute $50 million to the IAEA to help create an LEU stockpile controlled by the Agency that could be made accessible on a non-discriminatory, non-political basis should other supply arrangements be disrupted.[7] The offer was contingent on the following two conditions: that one or more IAEA member states contribute an additional $100 million in funding or an equivalent value of LEU, and that the IAEA takes the necessary actions to approve the establishment of the reserve. The first requirement was met in March 2009, but the IAEA Director General's proposal to prepare a detailed scheme on how an IAEA LEU bank for assurance of supply would be established and operated was in June 2009 rejected by developing members of the IAEA Board of Governors who saw the fuel bank as threatening their Article IV "inalienable right".
- **Russian LEU Reserve Proposal** (June 2007). As part of its initiative to establish an international uranium enrichment center, the Russian Federation proposed the creation of a guaranteed reserve of 120 metric tons of LEU in Angarsk. Russia agreed to cover all the costs associated with the establishment of the LEU reserve, its storage and maintenance, the application of IAEA safeguards, and ensuring safety and security. Following a request from the IAEA Director General to withdraw material from the reserve, Russia would deliver the required amount of LEU to the IAEA with all the necessary export licenses and authorizations required under Russian law. The IAEA would not own an LEU reserve, but would control and assure the supply of material from the reserve to a "non-nuclear-weapon State member of the IAEA experiencing a disruption in the supply of LEU for nuclear power plants not related to technical or commercial considerations".[8] In November 2009, the IAEA Board of Governors approved the establishment of the Russian guaranteed reserve of LEU[9] and in March 2010 the IAEA and the Russian Federation signed an agreement to establish the world's first international LEU bank at a uranium enrichment facility in Angarsk.[10] As Director General of the State Atomic Energy Corporation "Rosatom" Sergey Kiriyenko said, about one-third of the reserve's planned stockpile would be accessible before the end of 2010.

Attractive and successful multilateral fuel cycle arrangements should address the reasons that may underlie states' decisions to acquire domestic sensitive fuel cycle technologies. Those reasons include a desire to ensure security of fuel supply and reduce external dependence on foreign suppliers; low confidence in existing suppliers; commercial interest in making profits from selling materials and services on the market; national prestige; and aspirations to acquire a "hedge" or "virtual" nuclear weapons capability.

By diversifying the roster of suppliers and offering last-resort instruments and additional legal tools to guarantee uninterrupted access to nuclear fuel, the proposed supplemental mechanisms focus primarily upon energy security and confidence. Fuel banks and assurance of supply mechanisms may address concerns about 'security of supply' reason for establishing domestic uranium enrichment capabilities. Even if this is an important task that should be further pursued, those proposals do not address concerns over profits or national prestige. They are vague at best about managing the back end of the nuclear fuel cycle. They do not address spent fuel management, which remains one of the greatest challenges facing nuclear energy production. Interim spent fuel storage and final disposal of radioactive waste is the area where the demand for multilateral cooperation may be highest.

None of the proposed supplemental mechanisms is designed to actually change the way in which nuclear technology is managed, namely the highly national control of nuclear activities. This can be achieved only through true multilateralization when all sensitive fuel cycle facilities for peaceful purposes would be under multilateral control and ownership and under IAEA safeguards. Only a true multilateral regime, however radical and unrealistic that idea may seem at present, is likely to remove existing tensions between the three pillars of the NPT and address concerns about discrimination inherent to the international non-proliferation regime.

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[6] IAEA, Communication dated 28 September 2005 from the Permanent Mission of the United States of America to the Agency, document INFCIRC/659, 29 September 2005.

[7] "Nuclear Threat Initiative Commits $50 Million to Create IAEA Nuclear Fuel Bank", NTI press release, 19 September 2006, <www.nti.org/c_press/release_IAEA_fuelbank_091906.pdf>.

[8] Russian Federation Initiative to Establish a Reserve of Low Enriched Uranium (LEU) for the Supply of LEU to the IAEA for its Member States, IAEA document GOV/2009/31, 21 May 2009.

[9] "IAEA Board Adopts Resolutions", 27 November 2009, <www.iaea.org/NewsCenter/News/2009/bog271109.html>.

[10] [80]"Agreement Signed for First International Nuclear Fuel Bank", 30 March 2009, <http://gsn.nti.org/gsn/nw_20100329_6830.php>.

The former Director General of the IAEA proposed the following progressive steps to craft a new multilateral framework that is equitable and accessible to all users of nuclear energy acting in accordance with agreed nuclear non-proliferation norms:

- assuring the supply of fuel for nuclear power plants;
- limiting future enrichment and reprocessing to multilateral operations; and
- converting enrichment and reprocessing facilities from national to multilateral operations over time.[11]

Some of the existing proposals in the field of multilateral approaches to the nuclear fuel cycle and assurance of nuclear fuel supply go in that direction. Those proposals can be can be categorized into two groups: new infrastructure proposals and multilateral facility proposals.

New infrastructure proposals:

- **Russian Global Nuclear Power Infrastructure** (January 2006). The Russian Federation outlined a proposal to create "a global infrastructure that will give all interested countries equal access to nuclear energy, while stressing reliable compliance with the requirements of the non-proliferation regime", including the "creation of a system of international centers providing nuclear fuel cycle services, including enrichment, on a non-discriminatory basis and under the control of the IAEA" as a key element in developing this new infrastructure.[12] The Russian initiative does not explicitly mention comprehensive multilateralization of the whole nuclear fuel cycle or some of its parts. But creation of the proposed global infrastructure, as well as of a new truly multilateral fuel cycle framework, is a complex endeavor that needs to be addressed through a series of progressive steps. Certainly the creation of a system of international centers providing enrichment and reprocessing services is a necessary step towards true multilateralization.
- **Austrian Proposal on Multilateralization of the Nuclear Fuel Cycle** (May 2007). Austria proposed true multilateralization of the nuclear cycle through two parallel tracks. The first track would focus on "building transparency and mutual confidence, and, crucially allowing IAEA to build a fully comprehensive picture of each State's nuclear capabilities and activities" through the creation of an IAEA "cradle to grave" information system. The second track would focus on eventual multilateralization of the fuel cycle facilities worldwide through progressive steps leading to "a legally binding international instrument [which] would limit the production or reprocessing of all nuclear material for civilian nuclear programmes to facilities under multilateral control".[13] The Austrian proposal also envisages pooling sensitive nuclear material in a limited number of multilateral storage facilities worldwide, under IAEA safeguards. This is the only proposal that presents a road map towards full multilateralization of the fuel cycle, even if many practical details of this plan are still to be defined.

Multilateral facility proposals:

- **Russian International Uranium Enrichment Centre** (January 2007). As a first practical step toward the creation of a "global nuclear power infrastructure", earlier propounded by Russian President Vladimir Putin, the Russian Federation has established a model International Uranium Enrichment Centre (IUEC) at the Angarsk Electrolysis Chemical Complex "to provide guaranteed access to uranium enrichment capabilities to the Centre's participating organizations". The IUEC was formally brought into existence with the signing of an agreement between Kazakhstan and Russian on 10 May 2007. Armenia and Ukraine have already joined the IUEC Agreement, and after buying stakes in the center they will become full IUEC members before the end of 2010.[14] The center is open for other states, which meet their commitments under the NPT and share the objectives of the IUEC. The center is envisioned as a mechanism for providing guaranteed supplies of uranium enrichment services first of all to its members, but not exclusively to them. The IUEC stockholders would either have guaranteed enriched uranium product, or a share in the profits. The IUEC is structured in such a way that no access to Russian enrichment technology or classified information will be granted to other members of the center. Actually the relevant technology is located in another facility, which does not currently form part of the multilateral arrangement.

[11] Mohamed ElBaradei, "Nuclear Energy: The Need for A New Framework", Berlin, 17 April 2008, <www.iaea.org/NewsCenter/Statements/2008/ebsp2008n004.html>.

[12] IAEA, Communication received from the Resident Representative of the Russian Federation to the Agency transmitting the text of the Statement of the President of the Russian Federation on the Peaceful Use of Nuclear Energy, document INFCIRC/667, 8 February 2006.

[13] Multilateralization of the nuclear fuel cycle: increasing transparency and sustainable security, document NPT/CONF.2010/PC.III/WP.34, 13 May 2009.

[14] 84"Official: Ukraine, Armenia may join IUEC uranium enrichment center". <http://www.ukrainianjournal.com/index.php?w=article&id=10176>.

- **German Multilateral Enrichment Sanctuary Project** (May 2007). Germany proposed the creation of a new multilateral enrichment facility established by a group of interested states in a special extraterritorial area called Multilateral Enrichment Sanctuary (MES), supervised by the IAEA.[15] The group of interested states will invite their national industries to set up a commercial MESP Enrichment Company, which will finance, construct, own and operate the enrichment plant. A host country would cede the administration and certain sovereign rights to the IAEA in a part of its territory, similar to a host state granting certain rights—including rights over a defined territory—to international organizations. The IAEA would administer the MES and act as the nuclear regulator and supervisor for the operation of the enrichment facility, the role which is normally carried out by a state body. The plant "would have to be constructed as a 'black box' and would therefore only be accessed and maintained by the supplier [of enrichment technology]".[16]
- **GSS Uranium Enrichment International Consortium Proposal** (October 2007). The Gulf Cooperation Council (GCC), an organization that includes Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates, put forward an initiative that invited all interested states of the Middle East to participate in the establishment of an international uranium enrichment consortium, which could be based in a neutral country outside the region.[17] All member states of the consortium in the region could thus secure the supply of nuclear fuel for their power plants, but they would not have access to enrichment technology (the supplier of the "black-boxed" technology was not specified). Unfortunately this initiative, the only multilateral proposal that originated from non-supplier states, has not been further developed or practically implemented.

The added value of those multilateral facility proposals lies in the fact that they present efforts to practically realize the most difficult second (limiting future enrichment and reprocessing to multilateral operations) and third (converting enrichment and reprocessing facilities from national to multilateral operations) steps needed to establish a new multilateral fuel cycle framework.

The Russian IUEC can be considered as a practical, although tentative, step toward placing an existing national enrichment facility in a nuclear-weapon state under some form of multilateral control. The IUEC does not have its own uranium enrichment capacity and would instead negotiate contracts for uranium enrichment services with the existing enrichment plant, Angarsk Electrolysis Chemical Complex. Russia offered to place the plant under IAEA safeguards. But due to budgetary constraints, the IAEA has not been able to start safeguarding the facility. Currently the IUEC and the enrichment plant are operated separately. The IUEC, however, may in the future become a stakeholder of the Angarsk enrichment complex. Other forms of merger between two entities may emerge.

More importantly, from all multilateral arrangements proposed over the past few years, the IUEC and the LEU reserve in Angarsk are the only ongoing multilateral projects today. They could serve as testbeds for multilateralization and provide important experiences and lessons applicable to future implementation.

The Russian side, however, controls the majority stake in the IUEC and it can therefore take all strategic decisions regarding the company without the support of other partners. Moreover, Russia has exclusive control over the enrichment plant itself, in which no foreign participation is currently envisioned. This leaves other partners not much room for their involvement and may be not enough to respond to their 'entitlement' motivation.

The German MESP offers an alternative model for future truly multilateral fuel-cycle facilities that would be consistent with a world moving toward nuclear disarmament. The proposed joint ownership of an enrichment plant, with no single party having the majority of stakes, could address 'national prestige' concerns and fears that the multilateral nuclear approaches seek to reinforce the current "two-tier" system of supplier and customer states. Of course, the creation of a MESP-type multilateral facility would require the support of current technology holders and their governments.

The GCC initiative offers a promising example of a regional approach to multilateralization, especially important as it is the only proposal originated from the customer side. Non-supplier states should have a right to establish multilateral facilities with partners of their choice and in the locations of their choice, provided that building those facilities is economically sound and one of the existing suppliers commits to furnish safeguarded black-box technology. Regional cooperation on multilateral nuclear fuel cycle projects could serve as an important trust-building measure, strengthening regional security and reducing suspicions among participating states about others' nuclear intentions.

[15] IAEA, Communication dated 30 May 2008 received from the Permanent Mission of the Federal Republic of Germany to the Agency with regard to the German proposal for a Multilateral Enrichment Sanctuary Project, document INFCIRC/727, 30 May 2008; IAEA, Communication dated 22 September 2008 received from the Permanent Mission of Germany to the Agency regarding the German proposal on a Multilateral Enrichment Sanctuary Project, document INFCIRC/735, 25 September 2008.

[16] IAEA, Communication received from the Resident Representative of Germany to the IAEA with regard to the German proposal on the Multilateralization of the Nuclear Fuel Cycle, document INFCIRC/704, 4 May 2007.

[17] Nicole Stracke, "Nuclear Non-Proliferation from a Gulf Perspective", FES Briefing Paper 3, Friedrich-Ebert-Stiftung, 2008, p. 5.

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