Fuel Cycle Management

Martine Letts
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Introduction

18.1 Since the IAEA Director Generals' Expert Group on Multilateralisation of the Nuclear Fuel Cycle reported in 2005, eleven developed proposals for multilateralisation of the nuclear fuel cycle have been advanced, all except three by states currently possessing fuel cycle technologies. The proposals vary in their scope and time frame and prospects for realisation.

18.2 All proposals aim to stem the proliferation risks associated with the spread of sensitive nuclear technologies by making participation in multilateral facilities economically and politically more attractive than developing national facilities, though all but the most ambitious proposals fall short of this aim.

18.3 Multilateralisation initiatives focus upon the most proliferation-sensitive aspects of the fuel cycle: uranium enrichment spent fuel reprocessing and spent fuel storage.

18.4 While there is debate over the adequacy of the present international fuel cycle management regime, there is growing momentum among some states towards multilateralising elements of it. Those who consider the present regime to be largely effective support some modifications to the regime to buttress the market, while those who anticipate a proliferation crisis due to the spread of sensitive nuclear technologies propose a more extensive re-structuring of the regime.[1] Both approaches would involve changes to the control structures of the fuel cycle in order to achieve a more satisfactory balance between preventing proliferation and the rights of states to the peaceful exploitation of nuclear energy, enshrined in Article IV of the Nuclear Nonproliferation Treaty (NPT).

18.5 No one is challenging the "right" for states to acquire the technologies for peaceful purposes. Rather, the question is whether there ought to be other arrangements that guarantee states in good standing within the NPT access to the needed materials without them having to embark on the problematic course of producing their own.

[1] The latter view is that of the IAEA Director General, see Julian Borger, "Mohamed Elbaradei warns of new nuclear age," *The Guardian*, 14 May 2009, Available online at http://www.guardian.co.uk/world/2009/may/14/elbaradei-nuclear-weapons-states-un.

18.6 Nevertheless, as most of the proposals have been put forward by supplier states and are limited in their prospects to escape the constraints of those states' export controls or have long lead times, they have received lukewarm support from customer states. Those with stable supply relationships are content with present market arrangements; those with concerns about the risk of politically motivated interruptions to the supply of fuel think the proposals fail to adequately address their concerns, at least in the short to medium term.

18.6 This lukewarm political support, coupled with the fact that most proposals deny access to multilateral fuel cycle services if the state making the request is not in good standing with IAEA safeguards (such as Iran) or are outside the NPT, limit the effectiveness of the proposals in reigning in states of proliferation concern. Proposals requiring states to forgo national facilities as a precondition of participation, such as the US HEU fuel bank, are politically unpalatable for many developing states and unlikely to succeed in limiting the spread of sensitive technologies.

18.8 The term multilateral, is used in its broadest sense incorporating "multilateral"(the broadest and most flexible term, referring to the participation of more than two actors), "multinational"(implying several actors from different states),"regional"(several actors from neighbouring states) and "international"(actors from different states and/or international organisations, such as the IAEA).

18.9 What follows is a brief outline of the eleven proposals and some tentative conclusions on how successful the idea of multilateralisation is likely to be. The politics of this matter may yet defeat the entire enterprise, given that this question is so closely tied to the perception that controlling access to nuclear technology in the interests of nonproliferation further consolidates the status of the nuclear haves and have nots, and deflects from the primary objective of nuclear disarmament. Some might call this sterile rhetoric, but it is none the less powerful.

Background

18.10 The concept of fuel cycle multilateralisation was first raised in 1946 in the Acheson-Lilienthal report, but did not receive serious consideration until the 1970s, as a solution to concerns over the future proliferation hazard posed by the plutonium stocks that would result from a projected large increase in civil nuclear power generation with a closed fuel cycle. These concerns ebbed in the 1980s with the unanticipated slowdown in civil nuclear construction and the drop in natural uranium prices that made a closed fuel cycle uneconomic. Ideas for multilateral control, this time focusing on the front end of the fuel cycle, surfaced anew in the late 1990s.

18.11 A vocal advocate for fuel cycle multilateralisation, IAEA Director-General Mohamed Elbaradei convened an Expert Group on Multilateral Approaches to the Nuclear Fuel Cycle in 2004, prompted by a perceived trend towards the weakening of the nonproliferation regime, as exemplified by the crises in Iran and North Korea. The Expert

Group's findings, reported in 2005, have had a strong influence on the numerous multilateralisation proposals subsequently put forward.[2]

18.12 More recent factors adding momentum to multilateralisation include the movement towards nuclear weapon free world movement and the resurgence of interest in civil nuclear energy production by new nuclear power states, making the legitimate spread of enrichment and reprocessing capabilities a real possibility in the near future.

Incentives or Restrictions?

18.13 All proposals take an incentive-based approach to multilateralisation.[3] In order to succeed, an incentive-based approach must attract the participation of states that would otherwise consider developing national enrichment or reprocessing facilities and therefore must address the reasons why states would want to develop such facilities: energy security, a desire to participate in the profits of enrichment, national prestige and a possible desire to leave open the nuclear weapon option for the future.[4] Most of the proposals focus upon energy security and profits, and some attempt to deal with national prestige by facilitating the participation of non-technology holders in multilateral facilities.

Why multilateralise?

18.14 Multilateralising the nuclear fuel cycle aims to stem the possible domino effect of additional states acquiring sensitive nuclear technologies (SNTs) for any one of the reasons states might have for acquiring them, which could fairly quickly undermine confidence in the NPT and the ability of the international community to effectively monitor compliance.

18.15 A multilateral approach aims to prevent this by removing the security of supply and economic reasons for constructing national facilities, ideally also decreasing the number of new facilities constructed, decreasing the number of states in possession of enrichment and reprocessing technology, and placing the remaining facilities under safeguards.

18.16 Participating in a multilateral facility would limit opportunities for an individual state to acquire sensitive nuclear technologies, increase the political costs of seeking such

[2] See "Multilateral Approaches to the Nuclear Fuel Cycle: Expert Group Report submitted to the Director General of the International Atomic Energy Agency," INFCIRC/640, 22 February 2005, IAEA, Vienna. For an evaluation of the Expert Group's findings, see Lance Joseph, "Multilateral Approaches to the Nuclear Fuel Cycle," August 2005, Issues Brief, Lowy Institute for International Policy, Sydney.

[3] A restrictive approach would require a reinterpretation of Article IV of the NPT prohibiting national pursuit of sensitive nuclear fuel cycle activities and, while perhaps more effective from a proliferation perspective, would be time-consuming and stands a good chance of failing as it would require states to resolve the longstanding issue of discrimination between nuclear technology supplier and customer states. An incentive-based approach is therefore the only feasible option in the immediate term.

[4] National Academy of Sciences, *Internationalization of the Nuclear Fuel Cycle: Goals, Strategies and Challenges* (National Academies Press: 2008) Available Online at www.nap.edu/catalog/12477.html, p23.

technologies, and, by making fuel cycle services more accessible to all states, remove the security of supply and Article IV rights smokescreen, thus exposing the real reasons why a state is seeking such technologies. Multilateral approaches would also deliver economic benefits to participants, particularly those with smaller nuclear programs, who may share in the profits of the exploitation of sensitive technologies and enjoy economies of scale.

18.17 Yet, if not carefully implemented, multilateralising the fuel cycle could create new proliferation dangers by accelerating the early deployment of high-risk technology by states not already possessing an enrichment or reprocessing capability, or promoting its unwarranted transfer to them.

18.18 To be effective in non-proliferation terms, any multilateral arrangement would have to ensure not only that the facility and its technology could not be misused, but that its product would also be subject to appropriate international controls over its storage, release, use and ultimate disposition.

18.19 While advocates of multilateral facilities have pointed to greater peer scrutiny of staff of different nationalities as a deterrent to diversion of materials, technology or know-how, A. Q. Khan's example of technology theft while at Urenco demonstrates the risks of multilateral arrangements.[5]

Eleven Proposals[6]

18.20 The extent to which multilateralisation realises the benefits and mitigates the risks outlined above depends upon the design of the initiative itself. The eleven proposals currently under serious consideration are different designs and combinations of three basic options for multilateralising the fuel cycle – assurances of supply, fuel banks and multilateral facilities.

18.21 As no one proposal will provide adequate incentives for all states, and some proposals are more ambitious and have longer lead times than others, a flexible, layered and incremental approach to multilateralisation may be required.[7] Simpler proposals lay important groundwork for the realization of more ambitious proposals, particularly in terms of political will and logistics. While the proposals will be examined individually here, it is important to consider them as mutually reinforcing steps towards a layered multilateral fuel cycle management regime.

18.22 Most of the proposals deal exclusively with the front end of the fuel cycle.

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[5] National Academy of Sciences, p43-4.

[6] Most recent evaluations of all fuel cycle proposals have counted twelve proposals: see Tariq Rauf and Zoroyana Vovchok, "Fuel for Thought" *IAEA Bulletin* 49:2, March 2008. This report does not include the EU Non-Paper, which provides criteria for evaluating the proposals rather than a distinct multilateralisation proposal.

[7] IAEA Director General Mohamed ElBaradei, quoted in Yury Yudin, *Multilateralization of the Nuclear Fuel Cycle: Assessing the Existing Proposals* (United Nations Institute for Disarmament Research: 2009), p3.

Assurances of Supply

18.23 Existing market arrangements for the supply of uranium may be backed up by fuel assurances offered by industry, supplier states or the IAEA, activated in the case of a disruption in supply to a particular state. Non-political disruptions to supply have been uncommon in the past and are unlikely in the future, and reactor operators have well-developed mechanisms in place to deal with them,[8] so assurances would need to focus on political disruptions to supply. If the details are agreed upon, they can be implemented relatively quickly. However they only address the security of supply motivation, rather than economic incentives to enrich, and they are only as effective as the credibility of the guarantees offered. Putting the conditions of supply bar high enough to prevent proliferation but not so high that it puts off the customer is a particular challenge.[9]

World Nuclear Association (WNA) Proposal (2006)

18.24 The WNA developed an assurance of supply concept that consists of three tiers of supply assurances (1) the existing market mechanisms; (2) collective guarantees by existing uranium enrichment companies supported by commitments from governments and the IAEA; and (3) government stocks of enriched uranium product. The second tier would be invoked only if there was a politically motivated disruption to supply unrelated to proliferation, at which point the IAEA would be informed, evaluate the customer state's claim and direct the enrichment companies to provide a back-up supply of fuel. The enrichment companies' commitments would be written into supply contracts with eligible states. If the enrichment companies could not meet these obligations, states could resort to the third tier, government stocks of enriched uranium. States would need to be in full compliance with IAEA safeguards and have renounced the development, building or operation of enrichment facilities in order to be eligible.[10]

18.25 The proposal is distinctive in that enrichment companies will collectively and equally supply enriched uranium in the case of a disruption. The inter-governmental process for implementing the proposal is relatively straightforward, requiring agreement at the IAEA and formalisation in an IAEA Information Circular, but would require numerous agreements between uranium enrichers and their national governments if the assurances mechanism is to be swiftly activated. The security of supply offered by the proposal may be insufficient for some states, especially those lacking a good relationship with an enricher country, as the second and third tier assurances could be impeded by national government export controls. Fuel fabrication also poses a problem as such facilities are usually located in the same countries as reactor vendors and enrichment

[8] National Academy of Sciences, p28.
[9] See Fiona Simpson, "Reforming the Nuclear Fuel Cycle: Time is Running Out," *Arms Control Today* (September 2008).
[10] "WNA Report on Security of the International Nuclear Fuel Cycle" 12 May 2006, World Nuclear Association, London, available online at http://www.world-nuclear.org/reference/pdf/security.pdf. The Report containing the proposal also recognizes the need for security of supply at the back end of the fuel cycle, but provides no detailed proposal as to how this might be realized.

providers,[11] making the assurances ineffective unless alternative fuel fabrication providers can be sourced or constructed in the customer state. The requirement that companies be adequately compensated for the cost of providing assurances may make the proposal costly.[12] The eligibility requirement that states forgo the development of enrichment capabilities remains unacceptable for many states.

Six-Country Proposal (2006)

18.26 Also known as the "Reliable Access to Nuclear Fuel" proposal, this modified version of the WNA proposal was made by the six governments offering commercial enrichment services on the global market: France, Germany, the Netherlands, Russia, the United Kingdom and the United States. States need not forgo the development of enrichment capabilities in order to receive assurances, but must not currently have such facilities, must have a safeguards agreement and Additional Protocol in place with the IAEA and have no outstanding issues under those agreements, adhere to international safety standards and be a party to the Convention on the Physical Protection of Nuclear Materials and Nuclear Facilities. While otherwise functioning the same way as the WNA proposal, this proposal replaces the second tier with government guarantees to permit exports of enriched uranium and guarantees to not oppose such exports from other enricher countries. The third tier of assurance, enriched uranium stock, would be held by a supplier state, but rights to control their use could be transferred to the IAEA to provide greater assurance of supply. [13]

18.27 This proposal provides more credible assurances as such assurances are governmental commitments and by not requiring each enrichment company to provide an equal share of the shortfall in supply in the event of a disruption, it is a more flexible assurance than those offered under the WNA proposal and is therefore more likely to be both reliable and effective.[14] Yet while not requiring states to forgo enrichment technologies, it imposes such stringent eligibility requirements that few eligible states would have difficulty accessing the global market anyway. There is also a strong possibility that most of the six states would have a similar attitude to a particular customer state, undermining the reliability of back-up arrangements.

IAEA Standby Arrangements System (2006)

18.28 Japan has proposed the establishment of an IAEA-administered database in which Member-States register their nuclear fuel supply capability, including uranium ore, reserves, conversion and fuel fabrication as well as enrichment, which would assist the IAEA and its members in identifying and preventing market failure. In the event of a

[11] National Academy of Sciences, p18.
[12] For a further discussion of all of these arguments, see Yudin p34-5.
[13] Yudin, p35-7. This proposal also mentions, in general terms, options for reliable access to and multilateralising reprocessing facilities, spent fuel storage, fuel fabrication, research and development and multilateral enrichment facilities.
[14] Yudin, p37.

disruption in supply, the IAEA would act as an intermediary in order to match the customer state with a new supplier. All states in compliance with an IAEA safeguards agreement are eligible.[15]

18.29 This complements the Six-Country Proposal in allowing all states with front-end fuel cycle capabilities to act as suppliers in the event of a disruption, softening the distinction drawn between suppliers and customers in the Six-Country Proposal. This inclusiveness could, however, be seen to be encouraging the spread of enrichment and reprocessing capabilities.[16] It is unique among the assurance proposals for including fuel fabrication services. Its focus upon monitoring and improving the transparency and functioning of the nuclear fuel market is intended to 'reduce the incentive to develop uncompetitive, small-scale enrichment and/or reprocessing capabilities within their [States'] national borders' by highlighting the economic benefits and security of supply offered by the international market.[17] Despite this, is unlikely to greatly enhance the incentives for states to rely upon the international market, even if operating in conjunction with the Six Country proposal.

Enrichment Bonds Proposal (2007)

18.30 This UK proposal sets out one mechanism by which the Six Country Proposal export assurances could be practically implemented. The bond would consist of an agreement between a supplier state government, recipient state and the IAEA, and would preclude the supplier government from preventing exports of enriched uranium to the recipient state, if in accordance with international law and nonproliferation criteria. The IAEA would determine whether or not the conditions had been met to allow the export of enriched uranium, and the supplier state would be obliged to comply with its decision. To be eligible for a bond, a recipient state would have to have a comprehensive safeguards agreement and Additional Protocol in place with the IAEA, be in compliance with both, and make commitments as to the peaceful use, no retransfer and physical protection of any enriched uranium received. The proposal has since received the support of the Netherlands and Germany.[18]

18.31 The transparency of the IAEA decision-making in acting as a 'guarantor' increases the credibility of the assurance. As with the Six Country proposal, however, the eligibility requirements are so stringent that it would be unlikely that states satisfying those requirements would not be able to purchase enriched uranium on the international market. It is also not inconceivable that supplier states would breach their international legal obligations, reducing the credibility of the bond.

[15] "Communication received on 12 September 2006 from the Permanent Mission of Japan to the Agency concerning arrangements for the assurance of nuclear fuel supply," INFCIRC/683, 15 September 2006, IAEA, Vienna.
[16] Yudin, p38.
[17] INFCIRC/683, p3.
[18] "Communication dated 30 May 2007 from the Permanent Mission of the United Kingdom of Great Britain and Northern Ireland to the IAEA concerning Enrichment Bonds - A Voluntary Scheme for Reliable Access to Nuclear Fuel," INFCIRC/707, 4 June 2007, IAEA, Vienna.

Fuel Banks

18.32 The concept of a fuel bank is an extension of the assurance of supply concept in which a quantity of enriched uranium is held by a country or the IAEA and disbursed to a state whose regular supply arrangements have been disrupted. The fuel bank may be either virtual (consisting of assured access by the bank administrator to a given quantity of enriched uranium, guaranteed by a state) or involve the physical possession of uranium in the reserve. The fuel bank mechanism also operates as a default mechanism where a state cannot access enriched uranium on the commercial market for political reasons.

18.33 Fuel banks may offer a more credible assurance of supply than bare assurances, however that credibility depends on who possesses the fuel, who decides when a disbursement should be granted and upon what criteria. The costs and practicalities associated with storing a fuel reserve pose a further challenge. The reliability of fuel fabrication services is a more acute problem for fuel banks, as it is not feasible to stock fuel assemblies for all different types of reactors, leaving the development of national fuel fabrication facilities, as South Korea has done, as the most effective way to ensure access.[19] It is understood, however, that fuel fabrication plants do not present the same proliferation threats as the other sensitive technologies being discussed.

US Proposal on a Reserve of Nuclear Fuel (2005)

18.34 The United States announced that it would downblend 17 tons of highly enriched uranium deemed in excess of national security needs to use as a reserve of nuclear fuel 'to support assurances of reliable nuclear fuel supply for states that forgo enrichment and reprocessing'.[20] Though the low-enriched uranium (LEU) would serve to complement any IAEA reserve and support IAEA supply assurances, the material would remain under US control and subject to obligations attached to US-origin material. These eligibility requirements and obligations prevent the proposal from delivering security of supply or any economic advantage to customer states in excess of the existing market. Its contribution to the multilateralisation of the nuclear fuel cycle will be marginal.

Nuclear Threat Initiative Fuel Bank (2006)

18.35 In 2006, the Nuclear Threat Initiative (NTI) provided the IAEA with $50 million for the establishment of an LEU stockpile under IAEA control to ensure fuel supply to customer states on a non-discriminatory, non-political basis. Two conditions attached to the funds: (1) that the IAEA receive another $100 million or equivalent value of LEU from Member-States for the establishment of the reserve and (2) that the IAEA take the

[19] Fuel banks are also considered as part of the Multilateral Enrichment Sanctuary Project proposal and International Uranium Enrichment Centre, but are contingent upon the establishment of those facilities and are not the sole focus of the proposal.

[20] "Communication dated 28 September 2005 from the Permanent Mission of the United States of America to the Agency," INCIRC/659, 29 September 2005, IAEA, Vienna. See also Yudin, p25-6.

necessary actions to approve the establishment of the reserve.[21] The first requirement was met in March 2009, but the IAEA Director-General's proposal to formulate a detailed plan of how the fuel bank would function was defeated by the IAEA Board of Governors in June by developing nations who saw the fuel bank as impinging upon their Article IV rights.[22] NTI has stated that it hopes the fuel bank will offer enhanced security of supply to customer states in compliance with their nonproliferation obligations and who have chosen to rely on the market rather than develop their own enrichment facilities.[23]

18.36 The IAEA Board of Governors' defeat of the Director-General's proposal highlights the aversion of crucial states to any proposal requiring states not to develop indigenous enrichment facilities. Despite this, the fact that the eligibility criteria and structure will be determined by the Board of Governors and administered by the IAEA makes the proposal the credible in terms of security of supply and the most likely to receive international support, should an agreement be reached, because the proposal has the input of both supplier and customer states. Two practical issues that will need to be resolved are how the LEU reserve held by the IAEA will be stored and how its price of will be determined.

Multilateral Facilities

18.37 Multilateral fuel cycle facility proposals involve either the construction of new multilateral enrichment, reprocessing or spent fuel storage facilities, or the conversion of existing facilities to multilateral control.

18.38 Multilateral facilities are the most effective mechanism for simultaneously offering security of supply, economic incentives, including economies of scale in the delivery of fuel cycle services and safeguards, and greater equality among supplier and customer states. Urenco and Eurodiff represent successful models for multilateral enrichment arrangements currently operating in the market.

18.39 The establishment of multilateral facilities creates unique challenges that will take time to resolve. The degree of control accorded to different stakeholders, including the IAEA, technology supplier state, host state and customer state participants must be carefully calibrated to maximize incentives and efficiency without increasing proliferation risks. The costs of working out new legal and commercial arrangements to establish such facilities must be factored into any calculation of their economic benefits. Arrangements with the host state need to be made in order to ensure that enriched uranium or spent fuel can be transported to and from the facility unimpeded.

[21] "NTI/IAEA Fuel Bank Hits $100 Million Milestone; Kuwaiti Contribution Fulfills Buffett Monetary Condition," NTI Press Release, 5 March 2009, available online at http://www.nti.org/c_press/release_Kuwait_Fuel_Bank_030509.pdf.
[22] "IAEA Board Splits on Nuclear Fuel Bank Proposal," *Global Security Newswire*, 19 June 2009, available online at http://www.globalsecuritynewswire.org/gsn/nw_20090619_5943.php
[23] "NTI/IAEA Fuel Bank Hits $100 Million Milestone; Kuwaiti Contribution Fulfills Buffett Monetary Condition," NTI Press Release.

Reprocessing Services

18.40 Proposals for multilateral facilities have tended to focus on multilateral enrichment facilities and, to a lesser extent, reprocessing facilities. Yet 75-100% of demand for enrichment services in 2030 would be satisfied by existing capacity,[24] and projected demand for reprocessing services will also be easily satisfied by existing capacity. Unfortunately the proposals are vague or silent on the areas where demand for additional fuel cycle services is most acute and the technical case for multilateral cooperation is perhaps strongest, interim and final spent fuel storage.

Comment [FSC1]: More exact figures than Glaser's would be helpful but I haven't been able to locate any quickly -- they're probably out there somewhere!

18.41 With the exception of Japan, all existing reprocessing plants are located in NWS or non NPT states; provision of reprocessing services is not something ever likely to be denied, since it could never be in the interests of the present range of suppliers to leave spent fuel unprotected with its plutonium content intact, especially in a nuclear aspirant state. That's not to say that states not themselves possessing reprocessing facilities, and prepared to forgo the option, should not have assurances that other reprocessing services will always be available as needed. On the other hand, the product of reprocessing, the separated plutonium, is not something that should be routinely returned other than as MOX fuel and then with delivery carefully phased in accordance with the principles of just-in-time to avoid the accumulation of stocks at the reactor site.

18.42 The reprocessing of spent fuel can significantly reduce the quantity and radiotoxicity of the nuclear waste left over for final disposal. Even so, there is no reason to suppose that present world capacity cannot meet all reprocessing needs for decades to come. The international business of reprocessing is already highly competitive with France, Russia and the UK willing to accept foreign spent fuel for treatment. That said, North Korea and India are two states outside the NPT regime with interests in the reprocessing game, and may yet challenge the relatively stable status quo. Paragraphs 18.45-18.49 below examine some other international reprocessing options in the context of two other proposals, the Russian *Global Nuclear Power Infrastructure* and *GNEP*.

Interim Storage/Final Disposal

18.43 Proliferation risks attach to the present practice of storing spent fuel, including the contained plutonium, and frequently for long periods, at the reactor site pending reprocessing or decisions on final disposal. For some situations, physical protection can also be an issue especially in light of concern about theft from terrorist groups. Spent fuel storage can be quite expensive for countries with small nuclear programs or research reactors only. IAEA studies have concluded that significant economies of scale would result were the storage task to be handled multilaterally. More to the point, concentrating storage in several regional sites and imposing IAEA safeguards over each would measurably assist in the IAEA monitoring role.

[24] Alexander Glaser, "Internationalization of the Nuclear Fuel Cycle," Paper prepared for the International Commission on Nuclear Nonproliferation and Disarmament, p13, available online at http://www.icnnd.org/latest/research/index.html.

18.44 The main problem with any multinational storage would be the likely lack of domestic receptivity in any potential host country. That the spent fuel in question a multilateral pedigree would probably render the whole arrangement even more unpalatable to domestic opinion. Cost estimates would also need to take into account long term liability issues, making long lasting, open-ended financial arrangements almost unavoidable. So far only the Russian Global Nuclear Energy Infrastructure proposal has contemplated the acceptance of other countries' waste, and even then the legislation only permits for waste from Russian origin fuel.

Global Nuclear Power Infrastructure (2006)

18.45 This Russian proposal involves a network of international nuclear fuel cycle service centres around the world, under IAEA control and providing those services on a non-discriminatory basis. Russia has proposed four types of fuel cycle service centres within its borders – an International Uranium Enrichment Service Centre (IUEC) at Angarsk, which it has already established, a reprocessing and spent fuel storage facility, a personnel training and certification facility and a nuclear research and development facility. While the details of the proposal remain vague, and Russia has only implemented the front end of its fuel cycle multilateralisation (see IUEC section below) its legislation permits fuel leasing and, were it to offer such services, it could greatly improve the incentives for states to rely upon the market for fuel cycle services and would give Russia a considerable competitive advantage over other suppliers.[25]

International Uranium Enrichment Centre (2007)

18.46 Russia established the IUEC as a model facility under its Global Nuclear Power Infrastructure at the existing Angarsk Electrolysis Chemical Complex. Rather than constructing a new facility, IUEC effectively multilateralise an existing facility by negotiating contracts for enrichment services with the Angarsk Electrolysis Chemical Complex that are guaranteed by the Russian government. This leaves management, operations and technology in Russian control, effectively 'black-boxing' the enrichment technology so that foreign participants cannot access it. IUEC operates as a joint stock company and provides guaranteed access to enrichment for participant states, who may join IUEC through an agreement with the Russian government, provided that they meet (undefined) 'established non-proliferation criteria'. Kazakhstan is currently the only participant state, however Armenia and Ukraine have already signed agreements to join the project in the near future and negotiations are continuing with Finland, South Korea and Belgium.[26]

[25] "Cradle-to–Grave Nuclear Fuel Supply Assurance Workshop: Industry's Potential Role," Workshop Report, 6 June 2007, Pacific Northwest Center for Global Security, Pacific Northwest National Laboratory, p3 available online at http://pnwcgs.pnl.gov/pdfs/NuclearFuelSupplyWorkshop.pdf.
[26] "Uranium Enrichment Division," Rosatom, available online at http://www.rosatom.ru/en/energy_complex/uranium_enrichment/.

18.47 Though the details as to how the IUEC actually functions are unclear, it provides a model as to how existing facilities could be multilateralised. As criteria for participation are vague and Russia retains a significant degree of control over the venture, it is unclear whether such a balancing of stakeholder interests would be acceptable to all states.

Global Nuclear Energy Partnership (2006)

18.48 This US initiative has both a domestic and international component, the international component being the establishment of a group of supplier states who would provide fuel cycle services (including spent fuel take back, reprocessing and recycling) reactors to customer states, who would forgo enrichment and reprocessing technologies,[27] though this requirement was later dropped.[28] GNEP also devotes considerable resources towards the research and development of new reprocessing and reactor technology to develop an economically viable closed fuel cycle. The domestic arm of GNEP was cancelled in April 2009, though the Department of Energy is still considering options for the international arm.[29]

18.49 As one of the only proposals focusing on the back-end of the fuel cycle, GNEP may provide sufficient incentives for states to rely upon the market for fuel cycle services, though the realization of GNEP is heavily dependent upon the successful development and commercialisation of new technologies. GNEP would, however, entrench the division between supplier and customer states and its stipulation that states forgo sensitive technologies encouraged many states, including Argentina, Australia, Canada, South Africa, South Korea and the Ukraine to consider their options before the 'window of opportunity' to become a supplier state closed.[30] It is also dependent upon continuing funding and political support of the US government, and the cancellation of the domestic arm of GNEP makes the future of the international arm very uncertain.

Multilateral Enrichment Sanctuary Project (2007)

18.50 Under this German proposal, a new commercial multilateral enrichment plant would be established by a group of states, in agreement with the IAEA, and administered by a company set up by those states. The plant would be situated in a host state that would cede sovereignty over the territory. The IAEA would control all movements of nuclear materials in and out of the territory and would act as the regulatory authority for those facilities. Enrichment services would be guaranteed to all states satisfying criteria

[27] Leonor Tomero, "The future of GNEP: the International Partners," *Bulletin of Atomic Scientists* 31 July 2008, available online at http://www.thebulletin.org/web-edition/reports/the-future-of-gnep/the-future-of-gnep-the-international-partners.
[28] Yudin, p31.
[29] Daniel Horner, "Part of GNEP Officially Cancelled," *Arms Control Today*, May 2009, available online at *http*://www.armscontrol.org/act/2009_5/Part_GNEP_canceled.
[30] Yudin, p32; Tomero.

set by the IAEA, and would not be required to forgo the development of indigenous enrichment facilities.[31]

18.51 The MESP proposal would provide its participants and other customer states with a high degree of security of supply and strong economic incentives, and abolishes the supplier/customer distinction that makes GNEP and IUEC unpalatable for customer states. The project raises unique practical, political and legal challenges, not least finding a willing host state, and would need to build on the progress made by the simpler multilateralisation proposals.

Multilateralisation of the Nuclear Fuel Cycle (2007)

18.52 This Austrian proposal provides a road map towards full multilateralisation of the fuel cycle and integrates many of the proposals outlined above. It consists of two tracks – the first involves increasing the transparency and confidence in the international fuel cycle by requiring states to report their nuclear activities to the IAEA, which would then publish a periodic review of the fuel cycle services market based on that information. The second track involves the establishment of a nuclear fuel bank, similar to the NTI proposal, to be administered by the IAEA, and the IAEA assuming the role of a virtual broker for all transactions involving fissionable or source materials. Existing fuel cycle facilities would be multilateralised in a similar manner to the IUEC and Angarsk Electrolysis Chemicals Complex, and new facilities would be multilateralised from the outset. Once all facilities were fully multilateralised, a legally binding international agreement would prohibit the national pursuit of sensitive nuclear technologies, moving from an incentive-based to a restrictive multilateral fuel cycle arrangements.[32]

Conclusion

18.53 Multilateralisation of the nuclear fuel cycle has garnered significant political momentum in recent years, as shown by the numerous proposals put forward to achieve layered and incremental re-structuring of the international fuel cycle.

18.54 Despite this, there are three main obstacles to the implementation of a multilateralised fuel cycle management system that would successfully stem the proliferation of sensitive nuclear technologies.

18.55 The first is the perpetuation of discrimination among supplier and customer states. All proposals, with the exception of the NTI, WNA and Austrian proposals, have been developed by supplier states. Greater consultation with and participation by customer

[31] "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 ," INFCIRC/727, 30 May 2008, IAEA, Vienna.
[32] "Communication dated 26 May 2009 received from the Permanent Mission of Austria to the Agency enclosing a working paper regarding Multilateralisation of the Nuclear Fuel Cycle," INFCIRC/755, 2 June 2009, IAEA, Vienna.

states might help ensure that proposals receive more support from those states who will ultimately determine the success or failure of the proposal in supporting nonproliferation.

18.56 Second, all proposals either explicitly or implicitly exclude states not complying with IAEA safeguards or outside of the NPT. A situation such as that currently unfolding in Iran would thus not be addressed by any of the above proposals.

18.57 Third, those proposals that are likely to be implemented in the short- to medium term, such as the assurances of supply and fuel banks, might not provide sufficient economic and energy security incentives for states with current plans to expand their civilian nuclear power programs, to not develop indigenous enrichment and reprocessing capabilities.

18.58 Spent fuel take-back as part of multilateral arrangements would greatly increase its attractiveness to customer states, but is only included in long-term proposals such as the Russian proposal and GNEP. However the domestic arm of GNEP has been cancelled and the Obama Administration has been silent on fate of its international arm. The Obama Administration is also less enthusiastic about reprocessing than its predecessor.

18.59 Fuel fabrication is a complicating factor in all front-end fuel cycle initiatives such as fuel banks – different reactors require customized fuel assemblies, and stockpiling fuel for every reactor would not be feasible. States could however develop national fuel fabrication facilities without posing an additional proliferation risk.

18.60 The longer term multilateral facility proposals are more likely to encourage states not to develop these capabilities, but may not be implemented soon enough to provide states currently expanding their nuclear programs with a sufficiently attractive alternative to developing sensitive nuclear technologies nationally.

18.61 Assurance mechanisms such as the WNA proposal and six-country proposal are likely to come online in the next few years but are unlikely to stem the spread of enrichment technology. The establishment of the NTI fuel bank depends upon how long it takes the IAEA Board of Governors to agree upon the details, which is not looking promising after the first discussions in June 2009. New multilateral facilities lack a compelling economic rationale, especially as present global enrichment capacity is likely to satisfy present demand until 2030. No supplier state is willing to multilateralise existing facilities in a manner that shares control as well as providing access to fuel cycle services.

18.62 It must be noted, however, that most countries with nuclear programs are not proliferators. For the large majority, they are concerned simply with reaping the benefits of peaceful nuclear energy. Energy security, including access to nuclear power on a timely, predictable and economically attractive basis is thus their principal objective. For the most part, furthermore, they recognise the risks of widely dispersed weapons-usable material, and understand the need for restraint. Still, many of these same countries find it difficult to accept the notion that some states are more equal than others in the peaceful

nuclear sector, and consequently are likely to reject the establishment of principles that further codify discrimination.

18.63 In this regard, any new binding international norm stipulating that sensitive fuel cycle activities must be conducted exclusively in the context of a multilateral arrangement and no longer as a national undertaking, would amount to a reinterpretation of Article IV of the NPT and the rights specified therein for each party to pursue their own national programs.

18.64 Such a reinterpretation might not be entirely impossible, but would likely only be agreed in the context of a broader negotiation in which all existing facilities wherever located, in NWS or elsewhere, would need to be subsumed into the new arrangement. Any new restrictions on independent national operations would need to apply to NWS and to non NPT as well as NNWS thus bringing them to the same level of obligation as the latter. Clearly, negotiating this would be a tall order, not least given the predictable resistance of existing industry and technology holders. And that is to leave aside other possible preconditions that most likely would include demands for additional steps regarding disarmament and summary conclusion of an FMCT. All of which would be a time consuming process at best.

18.65 In the absence, therefore, of any near term new binding or universal norm, the best that might be hoped for is a voluntary arrangement in which, in return for assurances of supply, recipient states would renounce the national construction and operation of sensitive fuel cycle facilities for the duration of the agreement. In practice, countries would enter or not into such an arrangement according to their individual perception of advantage. The hope would have to be that a satisfactory experience in a multilateral venture in securing reliable and adequate supplies of fuel and services would lead most states to conclude that this way of meeting their nuclear requirements was preferable to a more independent, but problematic alternative.