

Proliferation Resistant Uranium Enrichment¹

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Executive Summary

Current International Atomic Energy Agency (IAEA) safeguards are incapable of ensuring timely warning of a diversion of materials or technology from civil uranium enrichment plants. The inability to provide timely warning stems from several factors, including:

- **the “breakout” scenario**—a state can withdraw from the NPT and its IAEA safeguards agreement, and divert to military purposes enrichment technology and enriched materials previously declared for peaceful use;
- **undeclared facilities**—some types of undeclared uranium enrichment facilities, such as small gas centrifuge and laser enrichment plants, can be hidden from inspectors and national technical means of surveillance for a considerable period, potentially long enough to produce a quantity of highly enriched uranium (HEU) sufficient to fuel a nuclear explosive device; and
- **covert acquisition and production**—national civil enrichment programs can provide cover for the importation and domestic manufacture of enrichment technology for military purposes.

When measured against these concerns, and what is required to allay them, only marginal improvement in the perceived durability of peaceful nuclear use commitments can be expected from current reform efforts, which are largely limited to: (1) improving material accounting and control; (2) increasing the frequency of IAEA inspections; (3) encouraging states to adopt the Additional Protocol which permits IAEA inspections of sites not declared as civil nuclear facilities; and (4) providing assurances of supply of enriched fuel for peaceful uses.

To begin addressing directly the international security concerns that accompany continued national acquisition of sensitive nuclear fuel cycle facilities, we propose a major supplement to current IAEA safeguards on enrichment plants, using the following criteria to guide proposed improvements:

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- the regime should be **universally applied** to all enrichment activities—in both weapon states and non-weapon states alike;
- the regime should be **non-discriminatory** in its application of safeguards;
- the proposed improvements should **strengthen, rather than diminish, the IAEA’s safeguards** role and functions; and
- the proposed improvements should **not interfere with the normal functioning of the international commercial marketplace for nuclear fuel services.**

With these criteria in mind, we believe the best way to improve safeguards over enrichment activities is to:

- (1) establish a new freestanding “International Nuclear Fuel Agency” (INFA), under the aegis of the United Nations (UN) and alongside the IAEA, to certify that the design, construction, and operation of all uranium enrichment facilities worldwide are conducted in accordance with strict nonproliferation and physical security criteria;
- (2) insure that all enrichment activities are conducted within long-term “Sovereign Secure Leased Areas” (SSLA’s) controlled by the INFA; and
- (3) have INFA “certify” the legitimate producers and closely track the certified end uses of key enrichment technology components which could be branded with tamper proof “tags” indicating their legitimate internationally certified origin.

Since INFA, a UN agency, would have extra-territorial rights over all sites where enrichment activities are conducted, it would be considerably more difficult for a state to use a plant constructed for peaceful civil purposes to support production of nuclear weapons. Any attempt by the host state to do so would represent an unambiguous threat to international peace and security and the international community as embodied by the United Nations. If the state attempted to take control of the site it would in effect be expropriating sovereign UN territory.

To be clear, the new agency, INFA, would not take over any functions of the IAEA. Rather INFA would ensure the IAEA’s immediate and unimpeded, if not continuous, access to sensitive facilities subject to IAEA safeguards, and INFA’s long-term presence, extending over the full operating life and decommissioning period of an enrichment facility, would represent both a strong political commitment to future peaceful use of the facility, and a significant deterrent to its future abuse in a nuclear weapons program.

INFA’s sovereignty over enrichment sites need not inhibit national or private ownership or commercially viable operation of the enrichment facilities located within such an internationally-regulated site.

Introduction

Credible technical and political concerns persist regarding whether current IAEA safeguards meet the fundamental standard of ensuring “timely warning” of the diversion from uranium enrichment plants of nuclear materials for military purposes. Timely warning requires that the interval between the diversion of safeguarded material and its detection by the IAEA be sufficiently brief, such that appropriate measures can be taken to prevent the government or organization concerned from further enriching the material and converting it into a nuclear explosive device.

It appears unlikely that the problems of treaty breakout, undeclared facilities, and covert acquisition and manufacture of sensitive nuclear fuel cycle technologies can be resolved satisfactorily without implementing some form of international and extraterritorial dominion over the sites where such national activities currently occur, or may be conducted in the future. Numerous proposals have been made by governments, the nuclear industry, international organizations and experts to strengthen international safeguards and security over uranium enrichment and nuclear fuel reprocessing, while also assuring an enriched uranium fuel supply. In two recent papers Pierre Goldschmidt, former deputy director general and head of the department of safeguards at the IAEA, has made several useful recommendations to strengthen safeguards over uranium enrichment and other nuclear activities.⁴ An excellent survey of twelve recent multilateral approaches has been made by Yury Yudin of the United Nations Institute for Disarmament Research.⁵

In what follows we propose a new international structure designed to radically improve the international community’s ability to ensure the peaceful use of uranium enrichment plants and related facilities, while making it more difficult and politically costly for states to misuse the technology. While going beyond the reach of current proposals to “reform” and “strengthen” the international safeguards system, our proposal nonetheless falls well short of longstanding but enduringly unattainable proposals for “international ownership and control” of the entire nuclear fuel cycle. We have sought to identify a middle ground that provides the added margin of security the world so clearly needs without invoking visionary schemes that the world is clearly not yet ready to adopt.

A political weakness of several of the proposals for strengthening safeguards over enrichment activities is that their proposed application discriminates between weapon states and non-weapon states, or between states that currently have enrichment plants and those that do not, or requires significant changes in existing commercial arrangements. Our proposal is designed to apply universally without discriminating between nuclear weapon states and non-weapon states. It also attempts to preserve the existing commercial structure for providing enrichment services without placing onerous or undue restrictions on commercial firms that provide these services. And in due course it could be expanded to include other sensitive nuclear fuel cycle activities.

⁴ See Pierre Goldschmidt, “Concrete Steps to Improve the Nonproliferation Regime,” Carnegie Papers, Carnegie Endowment for International Peace, 2009; and “Multilateral Nuclear Fuel Supply Guarantees and Spent Fuel Management: What are the Priorities,” to be published in January 2010 in *Daedalus*, 139 (1) (Winter 2010).

⁵ Yury Yudin, *Multilateralization of the Nuclear Fuel Cycle: Assessing the Existing Proposals*, United Nations Institute for Disarmament Research (UNIDIR), (Geneva: United Nations Publications, 2009).

Central Elements of the Proposal

The central element of our proposal is the establishment of a new freestanding “International Nuclear Fuel Agency” (INFA) alongside the IAEA under the aegis of the UN.⁶ INFA would certify the configuration for peaceful use and continuing operation of all uranium enrichment enterprises that seek to supply nuclear fuel cycle services to the global marketplace, or receive services from it. INFA would confine and supervise the conduct of these activities within “Sovereign Secure Leased Areas” (SSLA’s) controlled by the agency for the duration of construction, operation and decommissioning of the facility. INFA would provide continuing close observation of all peaceful uranium enrichment activities worldwide. INFA’s on-site presence would provide a continuous capability for making recurring certifications that enrichment activities located within its purview have not, are not, and cannot be used directly for, or contribute enriched product to, the production of fissile materials for nuclear weapons without triggering an unambiguous, timely, high-confidence advance warning of such illegal activity. Issuance of such a warning would in turn lead to an immediate set of prescribed INFA/IAEA security responses at the site and swift referral to the Security Council for further action. INFA’s purview would apply equally to enrichment activities in weapons and non-weapons states, including facilities not covered under existing IAEA or EURATOM safeguards.

In short, INFA’s legal sovereignty over the site and continuous presence is intended to enable improved performance of four key nonproliferation functions:

- The first concerns IAEA’s normally *retrospective* safeguards function, i.e., to more accurately determine what has actually occurred within a prescribed interval at the enrichment facility and detect any diversions or anomalies in relation to a country’s or an enterprise’s legal obligations under the NPT and relevant agreements with the IAEA and INFA.
- The second function is to provide a safeguards capability with a better *predictive* component. Countries want to know not only what potential adversaries have already done that might erode their nuclear peaceful use commitments, but also what they might be *capable* of doing within a given time period, and what the totality of the evidence suggests they are *intending* to do. Just as the IAEA reviews new plant blueprints and recommends design changes to improve safeguards, INFA and the IAEA would jointly exert similar authority over the physical configuration of future enrichment plants to enhance confidence in their exclusively peaceful use for the production of low-enriched material. With a continuous on-site presence, INFA could certify and monitor any proposed modifications to the facility to ensure that these are constrained technically to the production of low-enriched material, and remain limited to exclusively peaceful purposes.
- The third function is essentially a *deterrent* one—embedding peaceful use enrichment facilities within a security zone under the sovereign jurisdiction of the UN considerably ups the ante for any government considering diverting or reclaiming such facilities for nuclear weapons use.

⁶ See the Appendix for a discussion of other proposals that involve some form of international control of various stages of the nuclear fuel cycle.

- The fourth function involves *enforcement*. To be responsive to situations where a national government, or an agency or group within a government chooses to violate its nonproliferation obligations, or the responsible government appears on the verge of losing control over the security perimeter of the international zone, or the country as a whole, we propose that INFA-IAEA-UN Security Council triumvirate establish the necessary standing authorities to quickly mitigate the security and proliferation risks. Such predetermined responses could range from halting material flows in and out of the plant, to, in the extreme case, physically disabling it, thereby significantly increasing the “conversion time” to weapons for the material-at-risk, and increasing the time available to the Security Council to mount an effective response.

The role of the IAEA would be strengthened, not diminished. IAEA would continue to establish safeguards requirements and conduct safeguards inspections, but under our proposal it would have easier—indeed assured—access to all facilities subject to INFA certification, and an enhanced ability to monitor facilities and to force changes in operations where a facility or operator is not in compliance with IAEA requirements. We recognize that our concept of a continuous international monitoring and security presence, with carefully delimited powers to ascertain, certify, and enforce compliance with a clear set of nonproliferation and security requirements—but otherwise not interfere with the commercial operations of the uranium enrichment business—falls well short of “international ownership and control” of the uranium enrichment business, or of the nuclear fuel cycle as a whole, as called for in some prior proposals.

There are several considerations that need to be addressed regarding any new structure for ensuring the exclusively peaceful use of nuclear fuel cycle activities, including:

- creation of INFA and its relationship to the IAEA
- scope and timing of certification activities with respect to enrichment and other stages of the complete nuclear fuel cycle
- international control and management structure of INFA
- certification authority of INFA
- territorial sovereignty
- enforcement of INFA agreements
- facility ownership and operations
- liability
- customer supply
- component manufacturing, testing and supply
- IAEA safeguards
- physical security
- health, safety and waste management
- INFA financing and economic issues

In the balance of this paper, we address each of these considerations and conclude with how our proposal differs from other proposals and what relevance it may have in the case of Iran.

Creation of INFA and the role of the IAEA

To ensure the credibility and independence of IAEA safeguards, INFA would be established as a separate independent agency of the UN operating in parallel with the IAEA. Alternatively, some observers have suggested that INFA could be established on a provisional basis as a semi-autonomous group within the IAEA. Were this done initially it could make this proposal easier to achieve and speed its implementation. However, unless this was seen as a stepping stone to free-standing agency status, it could weaken the long term effectiveness of INFA by encumbering it with some of the weaknesses associated with the current structure of the IAEA. It could also lead to confusion between the traditional safeguards role of the IAEA, and the narrower mission of INFA proposed here.

The relation of INFA to the UN would be similar to that that of the IAEA as described in IAEA, INFCIRC/11, 30 October 1959. The INFA would have periodic—at least annual—reporting requirements to the UN General Assembly, and, like the IAEA, the obligation to submit reports to the Security Council “whenever, in connection with the activities of the Agency, questions within the competence of the Council arise.”⁷ INFA’s responsibility to the IAEA would be to ensure access by IAEA staff to enrichment facilities certified by INFA, facilitate IAEA (or where appropriate EURATOM) monitoring activities, and take appropriate actions where facilities were not in compliance with safeguards or security requirements, e.g., restrict or terminate the flow of materials into and out of the site, or in the extreme case, impose a complete shutdown.

States joining the INFA would have to ratify and implement a new “Additional Protocol on Isotope Separation and Enrichment” [hereafter, “Additional Enrichment Protocol (AEP)”] to existing safeguards agreements between the IAEA and all State-members of the IAEA. Under the AEP, member States would agree to the kinds of arrangements set forth below.

States that have not agreed to the proposed AEP, *and* the existing Additional Protocol providing for IAEA inspections of undeclared sites, would not be eligible to receive fuel cycle services from states that have agreed to the AEP. Similarly, states that adhere to the AEP agree not to accept fuel cycle services from any State that has not agreed to it. This would provide a strong incentive for all states that have enrichment plants and enriched uranium-fueled reactors to ratify the AEP.

Today uranium enrichment services are dominated by a few commercial and mostly state-owned enterprises, namely, EURODIF (services marketed by Areva), URENCO, Rosatom (foreign services marketed by TENEX), and the recently privatized U.S. Enrichment Corporation (USEC), with large uranium enrichment plants located in the United States, France, United Kingdom, Netherlands, Germany and Russia. The establishment of the INFA would of course require the approval of the UN General Assembly and the full cooperation of the IAEA, as protocols to existing safeguards agreements would be the primary means of implementation. But if the six major enrichment supplier countries agreed to establish and implement the AEP, it would be difficult for other enrichment service supplier- and user-countries not to join. By

⁷ INFCIRC/11 30 October 1959, p. 3, www.iaea.org/Publications/Documents/Infcircs/Others/infcirc11.pdf

staying outside the arrangement, they would be locked out of the commercial enrichment market and access to cost-effective enrichment and fuel fabrication services.

Scope and timing

As noted, INFA's first mission would be to bring within its jurisdiction all uranium enrichment activities, including those not covered under existing IAEA safeguards. This could be followed, or even accompanied, in certain cases, by extending its jurisdiction to cover:

- uranium conversion activities between the production of uranium concentrate (U_3O_8) and safeguarded fuel fabrication plants; and
- any other intermediate product storage sites that, in the view of the Agency, pose a state-sponsored diversion or breach of physical security issue.

Once these front-end facilities are covered and INFA has gained operational experience, the international community could address whether to expand coverage to other sectors of the nuclear fuel cycle, e.g., whether to incorporate back-end fuel cycle facilities. This paper concentrates on what would be INFA's initial and most proliferation sensitive priority—uranium enrichment plants.

International Control and Management Structure of INFA

We suggest the following governing structure of INFA for consideration. INFA would have a Board of Directors and an Executive Committee of the Board. The Director General of the IAEA (or his designated representative) would have a permanent seat on the Board of INFA and on its Executive Committee, but could not be an executive officer of the agency. The Board would have the responsibility for establishing INFA policies and procedures.

The Secretary General of the UN and the Director General of the IAEA would jointly propose a candidate for Chairman of the Board of INFA, whose selection would require ratification by a 3/5 majority of the Executive Committee and of the full INFA Board. The Chairman and the Executive Committee of the Board of INFA would be responsible for granting and enforcing the terms of INFA certifications covering the design, siting, and operation of uranium enrichment plants for exclusively peaceful purposes. The Executive Committee would nominate, and the full Board of INFA would approve the Executive Director for Operations of INFA, who would be the head of the INFA staff.

Each member State of the IAEA that has:

- a) Commercial enrichment facilities that supply at least one million kg "Separative Work Units" (SWU) per year to the commercial market, and/or;
- b) Sufficient commercial nuclear power reactors that together utilize three million kg SWU per year;

would be entitled to a seat on the Executive Committee of the Board of INFA. Using these criteria France, Germany, Japan, Netherlands, Russia, the United Kingdom, the United States and China would hold the initial seats on the Executive Committee. To meet the predictable objection that such an Executive Committee would comprise an oligopoly of advanced nuclear industrial states, additional rotating seats on the committee could be allocated to countries with smaller nuclear power sectors.

Members of the Executive Committee would serve as permanent members of the Board of INFA. The agency's founding agreement with the UN would establish the criteria and selection procedures for wider Board membership, the requirements applicable to all members for becoming and remaining a member in good standing, and procedures for the removal of Board members who fail to uphold these standards.⁸

The Executive Committee would nominate, and the Board of INFA would approve, the senior officers of INFA. INFA would establish a schedule of tariffs on enrichment services sufficient to cover the full cost of its operations. Since the SWU-cost represents a small fraction of the levelized, fully-amortized cost of nuclear-generated electricity, these tariffs would not adversely affect the economic viability of nuclear power.

Certification Authority of INFA

The host state's nuclear regulatory authorities would continue to exercise licensing authority over uranium enrichment activities. Certification by INFA would be limited to a determination of whether facilities have been designed and constructed and are being operated in compliance with INFA requirements set forth in its UN charter, INFA agreements with the IAEA, the Additional Enrichment Protocols, and INFA-State and INFA-Facility Agreements.

Under our proposal INFA would certify existing and new uranium enrichment and subsequently other nuclear fuel cycle facilities that may come under INFA's purview. Whether some or all of the additional facilities brought under its purview would likewise require enclosure in SSLAs, or merely rigorous international certification and improved safeguards, could be left to the discretion of the INFA Executive Board based on the professional recommendations of its staff and recommendations received from participating governments.

The INFA-State and INFA-Facility agreements would set forth basic threshold requirements related to ownership, operations, safeguards, physical security, and observance of existing international standards and conventions for protecting environment, safety and health.⁹ The agreements would specify limits on:

- enrichment level, e.g., U-235 concentrations would be limited to levels under 20 percent, depending on customer requirements;
- plant capacity and configuration;
- inventories of feed materials and enriched product stored at the site, or other intermediate storage sites if these are specifically permitted by the terms of the INFA-State agreement.

⁸ In addition to the initial eight members of the Executive Committee, a reasonable proposal for constituting the remainder of the full INFA Board would be to allocate seats to the 10 additional countries that currently have national fuel cycle facilities under IAEA safeguards—Argentina, Belgium, Brazil, Canada, India, Iran, South Korea, Romania, Spain, and Sweden – plus the largest suppliers of uranium (e.g. >3000 tons/U/yr in 2008) to the world market not already included on the preceding two lists—Australia, Kazakhstan, Namibia, and Niger. Together these lists yield a potentially inclusive but manageably-sized 22-member Board for the Agency, with the caveat that not all countries may qualify immediately for membership because of their failure, in the view of the Secretary General, to conduct their activities “in accordance with the Purposes and Principles of the United Nations Charter, and in conformity with the establishment of safeguarded worldwide disarmament and in conformity with any international agreements entered into pursuant to such policies.” See INFCIRC/11 30 October 1951, Article 1, Principles, para. 4.

⁹ For example, to help ensure future peaceful uses, these agreements could preclude ownership or operation of enrichment plants by military establishments or other bodies with national defense functions.

From a purely technical and economic perspective, global demand for uranium enrichment services could readily be met for the next several decades by upgrading technology and expanding capacity at existing uranium enrichment and conversion plants. Nonetheless, additional countries may wish to enter the enrichment market by constructing new facilities, possibly using new and more efficient technologies, or for reasons that are unrelated to ensuring security of fuel supply, such as a uranium-exporting nation desiring to add value to its exports of uranium concentrate.

Before INFA could render a judgment on formal requests from a member state to certify a new enrichment facility, or expansion of an existing plant, the agency staff, in consultation with the relevant staff of the IAEA, would be required to prepare a “Nonproliferation Impact Statement” analyzing: the civil purpose and economic rationale for the facility in light of other available sources of supply; the local and regional security environment for the facility; potential proliferation risks and impacts of the facility; and reasonable alternatives to it that could satisfy its proposed legitimate purpose and need.

While INFA would not have any direct environmental and safety oversight or enforcement authority, INFA staff would have a binding fiduciary obligation to report environmental abuses and safety concerns to the cognizant environmental, nuclear safety, public health, or occupational health and safety authorities of the host nation. INFA would also require that any formal request for certification be accompanied by an environmental impact statement, prepared by the appropriate national nuclear licensing or environmental protection agency of the government concerned, demonstrating facility compliance with all applicable international and national standards for radiation protection, nuclear security, radioactive and hazardous waste disposal, groundwater protection, and any other environmental requirements that apply to the facility under domestic or international law. INFA would have no formal authority to review the adequacy of or demand changes in this document, but would consider its findings and conclusions as part of any decision to certify a facility.

Territorial Sovereignty

The INFA would be granted the mandate and authority to lease—for one dollar per year—“Sovereign Secure Leased Areas” (SSLAs) under long-term agreements with the host nations. INFA would enter into such agreements with each state currently hosting, or planning to host uranium enrichment (and in due course other nuclear facilities), for the purpose of establishing extra-territorial rights, physical security and other arrangements outlined below. The INFA-State Lease Agreements would confer on INFA for a defined period (e.g., 50-99 years), or until such time as the covered nuclear facilities have been decommissioned., extra-territorial leasehold rights over all sites where uranium enrichment takes place or where new facilities are under construction.¹⁰

The INFA’s extra-territorial leasehold rights over the SSLA would remain in force even if the state chose to withdraw from the Nonproliferation Treaty (NPT) or its safeguards agreement with the IAEA, further curtailing any submerged motivations to acquire nuclear fuel cycle facilities as part of a dual-investment national security hedging strategy leading potentially to nuclear weapons acquisition at some later date. In short, a nation’s major investments in civil nuclear

¹⁰ This would be similar to the Multilateral Enrichment Sanctuary Project (MESP) under the German proposal. See the Appendix of this paper for a brief description and references.

fuel cycle facilities would not be recoverable for later use in a weapons program without making war on the international community—a fairly high bar to such future “breakout.”

No state party to an AEP, or commercial entity in such state, would be permitted to construct or operate a uranium enrichment facility—or a uranium conversion facility should an SSLA requirement be established for facilities of this type—except within an SSLA where the INFA enjoyed such extra-territorial rights. States would in effect relinquish sovereignty over the SSLA for the period of construction, operation and decommissioning of the enrichment facility, but their state-owned or commercial nuclear suppliers would continue to manage and operate the facilities located within the zone.

Safeguards and an IAEA-INFA Agreement

The IAEA would retain responsibility for establishing safeguards requirements, conducting safeguards inspections and enforcing the terms of safeguards agreements. The IAEA would prepare an IAEA-INFA Agreement. This agreement would set forth the steps that INFA must take in the event that the IAEA finds that any state or INFA certified facility is not in compliance with an IAEA-State safeguards agreement. For example, INFA’s authority and obligations in this connection could include the following hierarchy of options: a) limiting the flow of materials into and out of the site; b) limiting personnel access to the site; c) shutting down any facility the IAEA deems not in compliance; d) taking operational control of materials and or equipment at the site; or in the extreme case, e) rendering the plant inoperable by disabling critical equipment.

The IAEA-INFA Agreement would provide the IAEA with unimpeded access to the site for the purpose of monitoring and enforcing IAEA safeguards, and provide the IAEA with the authority to establish independent monitoring of materials, equipment and personnel entering and leaving the site.

Physical Security

We propose that the responsibility for day-to-day physical security would continue to be the responsibility of the host nation, as it is today. On-site physical security would continue to be a shared responsibility of the host nation and the commercial operators in states where this is the common practice. The INFA, under its host state Agreements, would be ceded the authority to establish at or inside the SSLA perimeter, whatever access controls and procedures are necessary for INFA to carry out its monitoring and security tasks.

One way that this might work would be as follows. The host nation would commit to ensuring the day-to-day physical security of an outer perimeter and buffer zone surrounding the SSLA. Access through a highly automated and remotely monitored inner security barrier into the SSLA containing the enrichment plant, and any associated storage and support facilities, would be exclusively through one or more portals controlled at all times by INFA personnel. Security perimeters and access controls at specific facilities and protected areas within the zone would be the responsibility of the individual commercial enrichment and conversion enterprises, which would continue to operate under private-, state-, or multinational ownership, much as they do today.

The Executive Committee of the INFA Board, however, would be ceded the uncontested overall authority to ensure site physical security and regulate the flow of materials and equipment to and from each SSLA. If at any time it is not satisfied with the physical security arrangements provided by the host nation, or in the event of a breach of the INFA-State Agreement or facility

agreement, then the Chairman and Executive Director of INFA could at their sole discretion supplement, replace or take command of the security forces at the site.

Such “Emergency Security Responses” (ESRs) would require explicit extension, modification, or reversal by the INFA Executive Committee within seven days, and similar consideration by the full Board within 30 days. But an ESR originating with or endorsed by the Director General of the IAEA in response to a safeguards violation could not be reversed by the INFA Executive Committee or INFA Board. In other words, the “default setting” of the system would favor and empower immediate responsive actions, rather than inaction, as is the case today.

A provision of the INFA-State Agreement would provide that in the event of war, civil strife, or credible warning of a terrorist threat to the facility, the Executive Committee of the INFA Board could call upon security forces of the UN, or any state or group of states represented on the INFA Board, to provide trained security personnel to bolster security at an INFA site.

Enforcement of INFA agreements

One of the weaknesses in the current safeguards regime is the lack of enforcement and the seemingly endless debate within the IAEA and the UN over what kind of sanctions to apply in the event a state is not in compliance with its IAEA safeguards obligations. Under our proposal, the State and facility agreements would include predetermined provisions and limitations on the activities of the facility and the host nation in the event of noncompliance with IAEA safeguards or INFA’s certification requirements.

INFA’s enforcement authority and obligations with respect to non-compliance with INFA-State and INFA-Facility agreements would be similar to those associated with non-compliance of IAEA agreements discussed above.

The Executive Committee of the INFA Board could be given responsibility for enforcing the conditions of both INFA agreements and of IAEA Safeguards Agreements when directed to do so by the IAEA or the UN Security Council. At a minimum, the Executive Committee would be granted the discretionary authority to restrict or end the flow of materials and equipment to and from any facility within an SSLA and to impound the materials, equipment, records and other assets at any covered enrichment or conversion site in the event that the Executive Committee believed there was an existing breach, or an imminent threat to breach, any of the conditions set forth in the INFA-State Agreement or facility license.

The Executive Committee of the Board could be granted the authority to call upon the UN, or any state or states represented on the INFA Board, to provide security forces if needed to enforce INFA’s certification requirements. In the case of less than severe disagreements or non-imminent threats, it would be obligated to take due care not to cause damage to the facility while resolution of the problem is under review. But when circumstances warrant, under its agreement with the private, national or multinational operating company, the INFA would have the authority to shut down or disable the enrichment facilities if a loss of Agency sovereignty over the site appeared imminent.

We believe the territorial sovereignty requirement and other aspects of this proposal will significantly reduce the likelihood that any host nation would attempt to break out of the international safeguards regime and use its enrichment facilities for weapon purposes. The INFA-State Lease Agreement would give rise to binding legal obligations that are independent of a state’s NPT and IAEA obligations. So, even if the state withdrew from the NPT and

terminated its IAEA Agreement, it would still be bound by its lease agreement with INFA, a UN agency.

Kicking the UN agency out would be tantamount to declaring war on the UN. Although there are few historical precedents, for the most part states have honored extra-territorial agreements that accord special status to foreign embassies and multinational agencies, and even former colonial territories, e.g., China honored the British lease of the Hong Kong territory until control was transferred peacefully under a diplomatic agreement. If a host State nonetheless did attempt to expel INFA and take over the site, the Security Council would have a stronger case for imposing sanctions or authorizing the use of all necessary means to prevent the use of the enrichment facility for weapon purposes.

We recognize that some states, at least initially, will seek to limit enforcement authority for INFA, a UN agency. The degree of enforcement authority granted INFA ultimately boils down to a trade off between an individual state's desire to exert ultimate control over sensitive fuel cycle facilities and its desire to live in a global and regional security environment that is significantly less vulnerable to NPT breakout, undeclared nuclear activities, and covert acquisition and manufacture of fissile material production equipment.

Facility Ownership and Operations

Capital assets at the enrichment and conversion sites would be owned by commercial entities, including private, state-owned, quasi-governmental, and multinational enterprises. The company or companies currently responsible for operating enrichment and conversion facilities would have to meet INFA's certification requirements. Similarly, new enrichment facilities built and operated by commercial entities would have to conform to INFA's certification requirements for such facilities. The management structure would be similar to the operation of enrichment plants by USEC, the "privatized" U.S. enrichment enterprise spun off from the Department of Energy in the 1990s, on sites that are still owned by the U.S. government. The difference here is that the plants would be located within secure international lease-hold sites under the long-term control of INFA, rather than on privately-owned land, or on national reservations controlled by the host-government.

Liability

The AEP and the INFA-State Lease Agreements would absolve INFA of any commercial, environmental, or personal injury liabilities associated with the INFA leasehold on the site. In effect, under our proposal apportionment of liability under existing national government laws and international conventions would remain unchanged, and the operating nuclear companies or consortia, (or their state shareholders) would remain the financially responsible parties.

Customer Supply

Customers would order enrichment services from enrichment facility operators, just as they do today. INFA would have the ultimate responsibility and obligation to insure that all financially solvent customers who are in full compliance with their IAEA safeguards agreements have an available source of enrichment supply. INFA could be granted standby authority, including access to a bridge financing mechanism, to be used as necessary in the event of a breakdown in commercial supply arrangements, to facilitate, if not overtly direct one or more enrichment

facility operators (and potentially fuel fabricators) to provide fuel cycle services to customers to insure that their needs for such services are met.

INFA would take over responsibility for managing existing and proposed buffer stocks—so-called “fuel banks”—of enriched product in the form of uranium oxide. Consequently, it is unlikely that INFA’s standby authority would ever be exercised, except possibly in the case of a disruption of fuel fabrication services to a customer otherwise in good standing.

Component Manufacturing, Testing and Supply

The INFA could be granted authority to maintain a list of sensitive uranium enrichment components materials, and equipment. Only manufacturers certified by the INFA would be permitted to produce such components. The INFA would approve the location and certify existing and new facilities that manufacture and test sensitive uranium enrichment components. Manufacturing and testing such components without a valid INFA certification would represent a serious breach of a country’s IAEA safeguards obligations and a crime under international law. Brokerage and resale of such components by third parties would be prohibited.

An even more secure option would be to require that all purchase orders for items on a short list of critical enabling enrichment components and equipment be placed through INFA, and that all shipping and delivery be handled by a small number of INFA-licensed shippers and routed as directly as possible from the factory to the customer’s plant, without transshipment or the use of intermediaries. INFA would maintain a secure registry and receive immediate notification of every such purchase order, shipment, and delivery. Each unit in a batch of sensitive components would be assigned a unique and difficult-to-replicate “tag” indicating its date and location of production and its status as an INFA-licensed product.

Products not bearing this tag could not be used in any new INFA-licensed facility or facility expansion, and the discovery of a tagged product in an uncertified facility would subject the producer to immediate loss of certification and potentially permanent exclusion from the legitimate commercial marketplace. The objective of this system should be obvious—to sharply differentiate between the legitimate and black markets for sensitive enrichment technology, in order to extinguish the latter. The incremental costs of this tightly regulated supply system—a necessary cost of reducing the proliferation risk of nuclear power generation—would be rolled into the agency’s tariffs levied on SWU’s and thus ultimately reflected in the downstream retail cost of nuclear electricity.

Health, Safety, Waste Management, and Supply Chain Certification

Initially, INFA would focus on assuring that enrichment facilities are complying with agreed practices for assuring that fissile materials are produced in a transparent manner and are not being diverted. At some later date consideration could be given to whether INFA’s role should be expanded to include responsibility for establishing and strengthening baseline international health, safety, environmental, and waste management and disposal criteria and requirements at facilities under INFA’s purview, and throughout the nuclear fuel supply chain. INFA’s role also could be expanded to include responsibility for enforcing these international standards.

Host nations would retain the discretion to establish more (but not less) protective health, safety, environmental and waste management standards, and the right to enforce facility compliance with these more protective standards. INFA would facilitate access by host-nation regulators to

examine environment, safety, and health (ES&H) records and make independent environmental measurements within the site security boundary. INFA would have the obligation to seek resolution of any data discrepancies.

The extension of INFA's authority into this realm would have the virtue of ensuring that competition in the future nuclear fuel supply chain is based on the comparative efficiency of mining and processing technologies and operations, and not on a "race to the bottom" propelled by exploiting national differences in environment, safety, and health standards or enforcement.

Agency Financing and Economic Issues

At current SWU prices, a modest tariff of perhaps five percent tacked on to the market price of a SWU would yield on the order of \$250 million per year to fund INFA startup operations. This tariff would have a negligible effect on the economics of commercial nuclear power, which is overwhelmingly a function of the capital costs of nuclear reactors. Because every enrichment market participant would pay these costs, there should be no adverse market impacts on an enrichment enterprise's comparative market position due to the imposition of this tariff.

An alternative would be for INFA to establish an annual fee to cover the cost of its activities at each facility or class of facilities under its purview.

The INFA would require similar surcharges on other stages of the fuel cycle as they are brought within its purview. The intent is for INFA to be largely if not entirely self-sustaining, based on the premise that its costs are a legitimate and necessary part of managing the risks associated with using the nuclear fuel cycle, and therefore deserve to be reflected in the retail cost of nuclear-supplied electricity. Detailing of member government laboratory experts for rotating tours with the agency, and other types of in-kind contributions, could obviously supplement the agency's budget, but would not be expected to play a major part.

Comparison with Other Proposals

We believe the proposal set out here is more comprehensive than and preferable to those offered to date. None of the other proposals, for example, address the weaknesses in the enforcement of current IAEA safeguards requirements, or the unregulated supply chain for key uranium enrichment plant components. It is also worth noting that our proposal does not conflict with most other proposals.

Seven of the twelve proposals compared in Yury Yudin's review for UNIDIR address nuclear fuel supply assurance.¹¹ These include:

- a September 2005 U.S. proposal for a reserve of nuclear fuel;
- a May 2006 World Nuclear Association's proposal;
- a June 2006 Concept for a "Multinational Mechanism for Reliable Access to Nuclear Fuel" proposed by France, Germany, the Netherlands, Russia, the United Kingdom and the United States;
- a September 2006 proposal by Japan for an "IAEA Standby Arrangements";
- the Nuclear Threat Initiative's September 2006 proposal for an "IAEA Fuel Bank";

¹¹ Yury Yudin, "Multilateralization of the Nuclear Fuel Cycle: Assessing the Existing Proposals," 2009.

- the United Kingdom's September 2006 "Enrichment Bond" Proposal (now called the "Nuclear Fuel Assurance" proposal); and
- the June 2007 Nuclear Fuel Cycle "non-paper" by the European Union.

Many experienced observers do not believe that "fuel assurance" is a serious issue for anyone save those who have enmeshed themselves in a serious unresolved IAEA safeguards problem, but if it *were* a serious issue, having access to enriched uranium hexafluoride, or enriched uranium oxide would not completely resolve it, because the customer still needs assured access to a fuel fabrication supplier, if not also a uranium conversion facility.

Under our proposal, the INFA is the ultimate guarantor of nuclear fuel services to all members in good standing who are in compliance with IAEA safeguards and have sufficient good credit to arrange payment for the services. Moreover, any of the fuel assurance proposals could be incorporated readily into our proposal by having the INFA manage the fuel bank and/or fuel assurance activities.

Other proposals reviewed by Yudin lack the universality and/or non-discriminatory aspects of our proposal:

- The January 2006, Russia's "Global Nuclear Power Infrastructure" proposal envisions creating a system of international centers for front and back end nuclear fuel cycle facilities under the control of the IAEA. In May 2007 Russia put forward the "Russian International Uranium Enrichment Centre at Angarsk. These proposals do not address existing or future national enrichment and conversion facilities that do not become international enrichment centers. In any case, the Angarsk Electrolysis Chemical Complex and similar centers could easily be incorporated into our proposal, although the centers would fall under the purview of INFA rather than the IAEA.
- In February 2006, under the George W. Bush administration, the United States proposed the "Global Nuclear Energy Partnership" (GNEP). The GNEP program as previously conceived has been terminated by the Barack Obama administration, although closed fuel cycle R&D will continue, and the cooperative diplomatic elements of GNEP related to assurance of fuel supply have been retained and may even be expanded.
- The May 2007, "Multilateral Enrichment Sanctuary Project" proposal by Germany is the prior proposal that most closely resembles our own. However, we believe we have strengthened the German proposal by expanding the sanctuary concept to apply to all enrichment plant sites, both existing and proposed, and by shifting supervision of non-safeguards issues—including new defenses against breakout—from the IAEA to a smaller, independent, and potentially more agile body, the INFA.
- The May 2007, "Multilateralization of the Nuclear Fuel Cycle" proposal by Austria is described by Yudin as a "vague, conceptual vision of eventually placing all sensitive nuclear technologies and activities, including existing civilian enrichment and reprocessing facilities and fuel supply, under multilateral control."

Relevance to Iran

Some have argued that our proposal does not adequately address current developments in Iran, or that it would simply allow Iran to continue to expand its enrichment facility at Natanz while this proposal is debated and developed. We do not suggest that our proposal by itself would “solve” the Iranian enrichment issue; rather we are looking beyond Iran—to strengthen the nonproliferation regime so the Iran issue is not repeated. Nonetheless, we also note that acceptance and implementation of our proposal by Iran would require the following:

- (1) Implementation of the Additional Protocol and conclusion of an Additional Enrichment Protocol (AEP);
- (2) A cap on the enrichment level, facility capacity, and amounts of LEU product and feed material stored on-site that would better protect IAEA timely warning objectives, and either:
 - a. prompt export to a foreign fuel fabricator,¹² or;
 - b. INFA-licensed and secured storage under IAEA safeguards at another site, remote from Natanz, of any excess low-enriched UF₆—allowance for such a site would be at the discretion of INFA, and only in response to a legitimate commercial fuel-cycle need, such as the eventual startup of an LEU fabrication facility within the country;
- (3) Long-term lease of the Natanz (and any other enrichment) site (e.g. 50-99 years) to INFA with extra-territorial rights conveyed to the agency, backed by the writ of the UN Security Council;
- (4) Formal certification of the Natanz operation by INFA, with a continuous on-site presence, complete access to every aspect of the operation by INFA personnel, and the regulatory discretion to shut it down, take possession of, or even disable the equipment in the event any irregularities or unsafe or insecure conditions were detected at the plant, or in the event of evidence of Iranian noncompliance with other aspects of its and IAEA safeguards and NPT obligations, that in the view of the regulator, merits such steps;
- (5) Declaration and closure within Iran of any other enrichment technology or production facility—such as the recently disclosed Fordow Fuel Enrichment Plant under construction near Qom—lacking international certification, which would be within INFA’s discretion to grant or deny;
- (6) To address the residual breakout threat involving the supply of natural uranium fuel to the heavy water reactor under construction in Arak, which in principle could produce weapons plutonium in a breakout scenario, the conversion

¹² We note that this solution, which we first advanced in a paper presented in Tehran in April 2006, is now part of the current discussions to resolve Iran’s dispute with the UN Security Council over its enrichment program and undeclared nuclear activities. See T.B. Cochran and C.E. Paine, “Ensuring the Peaceful Use of Iran’s Uranium Enrichment Capability,” paper presented at the Pugwash Conferences Workshop held in collaboration with the Center for Strategic Research, Tehran, 24-25 April 2006, <http://www.pugwash.org/reports/rc/me/tehran2006/Cochran-paper.pdf>.

facility at Isfahan could be placed within an INFA-SSLA simultaneously with the creation of an SSLA for the Natanz plant;

(7) Going forward, the use in the Natanz facility of only INFA certified parts— Iran’s reliance on clandestine supply networks would be terminated and compliance would be ascertained through intrusive inspections; and

(8) An INFA charter from the General Assembly that would provide for direct referral of serious breaches of Iran’s AEP to the UN Security Council, with INFA’s Executive Board, in consultation with the Director General of the IAEA, jointly determining what constitutes a serious breach meriting immediate referral.

One can certainly allege that none of the measures individually or cumulatively would make a difference in the level of proliferation risk posed by Iran’s program, but we do not find this assertion credible. The above measures collectively would substantially reduce the proliferation risk. Whether this reduction would be a sufficient basis on which to resolve the current impasse with Iran; whether Iran is likely to accept and faithfully implement such a proposal; and whether Israel could derive sufficient security assurance from it, are of course matters for debate, and perhaps resolution in further detailed agreements tailored to the specifics of the Iranian situation.

INFA would have inherent powers and discretion to mitigate, or even further reduce to very low levels, the risks posed by Iran’s enrichment program and other national programs that are likely to follow. Once established, INFA would have inherent powers to certify the design and operation of new enrichment facilities in countries and at proposed sites that it deems suitable and appropriate. INFA could develop sound objective criteria, relating to a host nation’s internal security, regional security, political stability, transparency of governance, and the economic viability of a domestic fuel cycle program, which would make it extremely unlikely that other countries in the Middle East would replicate Iran’s path anytime soon.

Afterword

While we believe our proposal offers great promise, we do not claim to have all the answers as to how such a regime should be structured. We strongly encourage participants in the global nuclear industry, U.S, foreign government and international agency officials, environmental regulators, and independent analysts to take this proposal seriously, refine it and promote its implementation. We have benefited greatly from comments on previous drafts of this proposal. We encourage readers to contact us regarding this draft, and give us your reactions, criticisms, and refinements. Through such a process, a more precise shared understanding of the nature of the problems, and likely sticking points, can be built.

Our respective emails are provided in footnotes at the bottom of page one of this document. Please address your comments to both of us to increase your chances of receiving a timely reply in the event that one of us is traveling or otherwise engaged.

If you would like to discuss the proposal in person, which we encourage, please indicate in your email when you are likely to be next in Washington, D.C. or New York, and we will do our best to accommodate your schedule. Depending on the level of interest and amount of travel involved, it may also be possible to meet with you at your company or agency offices at sites outside New York or Washington.

Appendix

Some Previous and Current Proposals For International Control of the Nuclear Fuel Cycle

Acheson-Lilienthal-Baruch Plan” of 1946. While the scheme proposed in this paper differs substantially from prior proposals for “international control,” the general concept of “internationalizing” various stages, or indeed all of the nuclear fuel cycle has a long history, stretching back to the original “Acheson-Lilienthal-Baruch Plan” of 1946 for comprehensive international control of intrinsically “dangerous activities” atomic energy activities, including an international monopoly on uranium mining and enrichment.

U.S. Nuclear Non-Proliferation Act of 1978. Although little remembered today, Section 104 of the U.S. Nuclear Non-Proliferation Act of 1978 [22 U.S.C. 3223 (a)] remains legally binding in the United States, and actually directs the President to “institute prompt discussions with other nations and groups of nations...with a view toward the timely establishment of binding international undertakings providing for:

- (1) “the establishment of an international nuclear fuel authority (INFA) with responsibility for providing agreed upon fuel services and allocating agreed upon quantities of fuel resources to ensure fuel supply on reasonable terms in accordance with agreements between INFA and supplier and recipient nations;
- (2) “a set of conditions ...under which international fuel assurances under INFA auspices will be provided to recipient nations, including conditions which will ensure that the transferred materials will not be used for nuclear explosive devices;
- (3) “...feasible and environmentally sound approaches for the siting, development, and management under effective international auspices and inspection of facilities for the provision of nuclear fuel services, including the storage of special nuclear material;
- (4) “the establishment of repositories for the storage of spent nuclear reactor fuel under effective international auspices and inspection;”
- (5) “the establishment of arrangements under which nations placing spent fuel in such repositories would receive appropriate compensation for the energy content of such spent fuel if recovery of such energy content is deemed necessary or desirable; and
- (6) “sanctions for violation of the provisions of or for abrogation of such binding international undertakings.”

In negotiating such “binding international undertakings,” Sec. 104 directs that the President “seek to ensure that the benefits of such undertakings are available to non-nuclear-weapon states only if such states accept IAEA safeguards on all their peaceful nuclear activities, do not manufacture or otherwise acquire any nuclear explosive device, do not establish any new enrichment or reprocessing facilities under their de facto or de jure control, and place any such existing facilities under effective international auspices and inspection” (emphasis added).

International Nuclear Fuel Agency (INFA) proposal, from *Uranium Enrichment and Nuclear Weapons Proliferation*, SIPRI, 1983. In view of the particular proliferation threat posed by the spread of multiple and relatively compact uranium enrichment technologies under purely national auspices, an extensive 1983 analysis by four technical experts affiliated with the Stockholm International Peace Research Institute (SPRI) concluded that “the enrichment industry should be internationalized, possibly along the lines of an international nuclear fuel agency (INFA).”

They proposed that “all national enrichment facilities should be brought under the authority of this agency, which would own and operate them in response to national demands for enrichment services.” Such an agency would be responsible for “the production, distribution, and safeguarding of enriched uranium.” In their scheme, “all research and development on uranium enrichment should be conducted by INFA,” further development of proliferation-prone centrifuge and laser enrichment techniques would be terminated, no new national enrichment facilities would be built, INFA membership would be required for the receipt of nuclear fuel services and would not be subject to a withdrawal provision, INFA would have “the power to enact sanctions against states that either violate their agreements or withdraw from the agency, and “technical and administrative aspects of safeguards on enrichment facilities should be improved substantially.” See Allen S. Krass, et al., *Uranium Enrichment and Nuclear Weapons Proliferation*, SIPRI (Taylor & Francis Ltd: London and New York, 1983), pp. 79, 88-91, and 207.

Security Assistance Act of 2008. Sec. 422 of S.3563, the Security Assistance Act of 2008, reported by the Committee on Foreign Relations to the full Senate on September 24, 2008, would require the President to report to Congress regarding “establishment of an international nuclear fuel authority,” and highlights Senate interest in some of the same issues considered in this paper:

“(a) Report Required—Not later than 180 days after the date of enactment of this Act, the President shall submit to the appropriate congressional committees a report detailing the feasibility of establishing an International Nuclear Fuel Authority (INFA) as called for in section 104 (a)(1) of the Nuclear Non-Proliferation Act of 1978 (22 U.S.C. 3223(a)(1)).

(b) Content—Without regard to any previous reports submitted under section 104 (a)(1) of the Nuclear Non-Proliferation Act of 1978 (22 U.S.C. 3223), the report required under subsection (a) shall evaluate, with respect to the feasibility of the establishment of the International Nuclear Fuel Authority, the following:

- (1) United States laws and regulations that could be affected by the establishment of an INFA.
- (2) What the cost to the United States Government could be of establishing an INFA.
- (3) Potential locations for the INFA.
- (4) The potential for creating a fuel supply bank under the control of the INFA.

(5) Nuclear materials that should be placed within the control of the INFA, including which nuclear activities should be carried out by the INFA for the production of nuclear fuel or for use as fuel.

(6) Whether the INFA should provide nuclear fuel services to recipient countries.

(7) Whether a multilateral supply mechanism, such as the INFA, is, in the judgment of the President, superior to bilateral mechanism for nuclear fuel supply.

(8) How such an international organization should operate to preserve freedom of markets in nuclear fuel and avoid undue interference in the efficient operation of the international nuclear fuel market.

(9) The degree and extent to which such a multilateral supply mechanism should be under the control of, or a subordinate organization within, the IAEA, including whether establishing such an INFA would be superior or preferable to allowing the IAEA, pursuant to Article IX of the Statute of the IAEA, to become an international broker of nuclear fuel and nuclear fuel services, including with respect to an examination of the costs to IAEA Member States of effectively carrying out clauses (1) through (4) of paragraph (H) of such Article.

(10) The likely receptivity of the major countries involved in the supply of nuclear fuel and nuclear services to the creation of a multilateral supply mechanism such as the INFA or one under the IAEA.”

Multilateral Enrichment Sanctuary (MESP), German Foreign Ministry, 2007. Our proposal has features that are similar in some respects to a May 2007 proposal from the German Foreign Ministry. MESP would be a multilateral enrichment facility established by a group of interested states on an extra-territorial basis in a host state and supervised by the IAEA, but owned and operated by a multinational commercial consortium. MESP is one of the twelve proposals reviewed by Yury Yudin in *Multilateralization of the Nuclear Fuel Cycle: Assessing the Existing Proposals*, United Nations Institute for Disarmament Research (UNIDIR), (Geneva: United Nations Publications, 2009) p. 18, proposal #10, also discussed in detail on p. 46-48 and Appendix D, “MESP Details.” For the original text of the German proposal, see <http://www.auswaertiges-amt.de/diplo/de/Aussenpolitik/Themen/Abroestung/Downloads/MESP-Sitzstaatsabkommen.pdf>

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