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Multilateral nuclear fuel supply guarantees & spent fuel management: what are the priorities?

Expectations for a worldwide expansion of nuclear energy have raised fears that states could potentially procure sensitive technologies used to manufacture nuclear weapons or explosive devices.[1] To cope with this problem, some have advocated that enrichment and reprocessing facilities be constructed and operated under multilateral arrangements. Such an approach is generally viewed as effective in ensuring safe and reliable access to nuclear fuel and services at competitive market prices while strengthening the nuclear nonproliferation regime by removing incentives for countries to develop indigenous fuel cycle capabilities.

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

This essay posits that further improvement to the reliability of fuel supply is best achieved by giving priority to fuel leasing contracts, coupled with long-term generic export licenses, and last-resort multilateral fuel supply arrangements. These arrangements are easier to implement in the short term, rather than much more complex multinational enrichment facilities. For neighboring countries starting nuclear power programs, setting up a fuel procurement consortium would provide safer and better fuel supplies than would their individual participation in a multinational enrichment facility.

Regarding the back-end of the fuel cycle, the development of multinational spent-fuel storage and geological disposal facilities will be relegated to the distant horizon due to the prevailing "Not In My Backyard" (NIMBY) syndrome. This is regrettable. Yet, as long as impediments to multinational spent fuel management remain high, it is most urgent to strengthen the International Atomic Energy Agency's (IAEA) verification authority and improve the likelihood of prompt and firm UN Security Council

action when a state is found to be in non-compliance with its IAEA safeguards or Nuclear Non-Proliferation Treaty (NPT) obligations.

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

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

Yet the fact that states with less than impeccable nonproliferation records could argue that they need to produce low-enriched uranium (LEU) domestically has recently raised new proliferation concerns. Indeed, once a country operates a uranium enrichment facility (for example, based on the gas centrifuge process) and has either an indigenous conversion plant or a stockpile of UF_6, it is technically in a position to produce high enriched uranium (HEU) suitable for nuclear weapons. HEU cannot be produced in a commercial enrichment plant (that is, one normally limited to producing uranium with less than 5 percent U-235) under IAEA safeguards without being detected. However, a commercial enrichment plant could potentially be quickly reconfigured to produce HEU if the state where the facility is operating withdraws from the NPT. There is also a risk that a small, undeclared replicate of the enrichment facility (based on the same domestic technology) could be operated clandestinely. Both Libya and Iran have been able to work for some 20 years on the development of centrifuge enrichment without detection by the IAEA, prompting increased international awareness that this is more than a theoretical possibility.

It is therefore urgent to develop a concept that would guarantee reliable access to fuel for nuclear power reactors in NNWS while providing maximum protection against the risks of nuclear proliferation. In my view, the best way to do so would be for supplier states to provide what I have described as long-term "generic export licenses."[2] These licenses consist of a bilateral agreement between the consumer and supplier states whereby the latter would provide a binding, long-term export license for nuclear fuel as long as specified nonproliferation, safety, and security conditions are met by the recipient state, including:

1. The recipient state has not issued a notice of withdrawal from the NPT.
2. The recipient state has concluded with the IAEA an INFCIRC/66-type safeguards agreement for the NPP under consideration. This agreement would normally be subsumed under the CSA, but would be implemented should the recipient state withdraw from the NPT, so that any fresh fuel or spent fuel re-

maining in the recipient state would invariably be subjected to IAEA safeguards.[3]

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

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

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

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

It would be the responsibility of the IAEA Director General to confirm that these conditions are met.

Multilateral approaches to nuclear fuel supply guarantees include multinational fuel procurement arrangements, multinational enrichment facilities, and the establishment of a nuclear fuel reserve.

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

Multinational Enrichment Facilities. Contrary to conventional wisdom, it is not necessarily in the interest of a state or company with a small nuclear program to become a minority shareholder in a multinational enrichment facility (MEF). Doing so would make the shareholder almost exclusively dependent upon one supplier, with little possibility of benefiting from the competition of multiple suppliers. Becoming a partner in a MEF is like getting married. Those entering such a project ought to know that getting divorced will be difficult, long, and costly.

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

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

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

The "Russian Initiative to Establish a Reserve of Low Enriched Uranium (LEU) for the Supply of LEU to IAEA for its Member States"[4] is a good example of such a multilateral fuel supply guarantee. The Russian conceptual mechanism for guaranteeing consumer states access to a physical reserve of 120 tons of LEU in the form of UF_6 is remarkable.[5] The UF_6 will be stored in Russia at the Angarsk International Uranium Enrichment Center (IUEC), under IAEA safeguards and free of storage, maintenance, or other costs for the IAEA. This fuel reserve will be made available to any NNWS member of the IAEA experiencing a disruption of LEU supply that is understood to be for political reasons "unrelated to technical or commercial considerations."[6]

The supply mechanism is made up of two agreements, both of which need to be approved by the IAEA Board of Governors. The first agreement, to be concluded between Russia and the IAEA, would provide that:

- Russia undertakes to make the requested amount of LEU (in the form of UF_6) available to the IAEA and to deliver the LEU to the IAEA for subsequent supply to the member state that has made the request to the IAEA; and
- Russia undertakes to issue without undue delay all necessary authorizations and licenses for the transfer of the LEU to the IAEA and for export and supply of the LEU to the consumer state.

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

1. The consumer state would have to be a NNWS member of the IAEA;
2. It must have "an *effective* Agreement with the IAEA requiring the application of safeguards on *all* its peaceful nuclear activities";
3. The IAEA has "drawn a conclusion that *all* nuclear material had been accounted for";
4. "That there was no indication of diversion of declared nuclear material";
5. "That there would not be any safeguards implementation issues concerning the State under consideration by the IAEA Board of Governors"; and
6. The consumer state would have to pay Russia the actual market spot price for LEU delivered, so that Russia would most likely "replenish" its physical reserve of LEU available to the IAEA.

Russia makes the supply of LEU available under the above conditions without requiring the consumer state "to forgo any rights, including rights to develop a country's national fuel cycle capabilities."[7]

Based on the first two conditions, the consumer state must be a NNWS member of the IAEA with a CSA in force. It

therefore excludes nuclear-weapons states and non-NPT states (India, Israel, North Korea, and Pakistan). What is not clear is the meaning of an "effective" safeguards agreement. Does it only mean "in force," or does it mean something more? For example, could it mean that the IAEA is able to implement fully all provisions of the CSA, including Subsidiary Arrangements conforming to the Board's requests (for example, Code 3.1 relating to the early provision of design information)?

Condition 3 implies that the consumer state has an Additional Protocol in force and that the Agency has drawn the so-called broader conclusion that there is no undeclared nuclear material (and activities) in the state as a whole. This conclusion implies that "no indication has been found by the Secretariat that, in its judgment, would give rise to a possible proliferation concern."[8] It is worrying that a Director General's report of May 21, 2009, describing the Russian Initiative to IAEA member states, no longer mentions this requirement as an "eligibility condition."[9] Did the Russian authorities change their position in the time between May 6 and 21?

Condition 4 relates to "*indication* of diversion of *declared* nuclear material," raising the question of what constitutes an "indication" and how such an indication would be brought to the attention of the Board before it approves the state-specific supply contract. For instance, would a cumulative quantity of Material Unaccounted For (MUF) of more than one significant quantity constitute such an indication? This type of information is usually only reported, if at all, in vague terms in the Safeguards Implementation Report (SIR) without naming the state in question.

Condition 5 is perfectly relevant. It should however be made clear that if a consumer state were to call upon the Russian/IAEA LEU fuel supply guarantee, the Board would require the Director General to make a full report to the Board on all nonproliferation-relevant information concerning that state, before approving the specific supply contract.

In addition to the six Russian conditions mentioned above, the MSA should provide, *inter alia*, that the LEU delivered is to be used exclusively for the fabrication of fuel assemblies, which will be loaded in specific electrical NPPs.

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

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

1. Storage after unloading at the NPP, first in a pond and then, possibly, in dry storage casks;
2. Storage at:
   a) a centralized facility where the spent fuel will be stored for a number of decades;
   b) a facility close to a plant where the spent fuel will be conditioned in a form appropriate for final (geological) disposal, either as spent fuel in appropriate containers or after un-

dergoing some mechanical treatment (for example, being cut into pieces) and encapsulation; or

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

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

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

For a country embarking on a new NPP program, there are, in the current environment, no economic or technical incentives to opt for spent fuel reprocessing, at least not during the first decade of operation. By far the easiest and least cost-intensive solution is to store the spent fuel for as long as possible at the NPPs. This is the solution that has been implemented by most nuclear electrical utilities in the world, but it raises the concern of having spent fuel containing plutonium in facilities scattered all over the world, which is vulnerable to potential theft, diversion, or misuse.

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

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

In addition, as a matter of good practice and to guarantee to the supplier state that the necessary funds will be available to cover future spent fuel management costs, the following mechanisms would be implemented. For each kilowatt-hour (kWh) produced by the NPP, a specified amount of money (often expressed in USD mills per kWh, or, "millage") would have to be paid monthly into a dedicated escrow account. This payment would cover all transportation costs of the spent fuel to the supplier state as well as all costs incurred for the management, storage, conditioning, and final disposal of the spent fuel assemblies after their return to the supplier state. The account would have to be managed by an appropriate international organization, such as the European Bank for Reconstruction and Development (EBRD), the International Monetary Fund (IMF), or possibly the IAEA.

If the supplier state is allowed by law to retain the spent fuel without having to return any radioactive waste to the recipient state, then the full amount of the corresponding millage would be released by the fund (with accrued interest) to the supplier state, after it has reimported the spent fuel. In some cases, however, the supplier may be legally obligated to include a contract provision

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

It is clear that the proposed fuel contract will be most attractive to the recipient state if it completely resolves that state's spent fuel and HLW management problems. Such would likely be the case only in a recipient state that has not yet accumulated a large amount of spent fuel from NPPs. When a recipient state has already accumulated spent fuel from one or more research reactors, the removal of spent fuel by the supplier state (under agreed-upon terms) would considerably increase the attractiveness of the supply agreement. By contrast, if the supplier state were to request that the vitrified HLW be sent back to the recipient state, this attractiveness would be reduced.

An important side benefit of this scheme is to guarantee that all costs related to the back-end of the fuel cycle would be included from the start in the price of electricity produced by the NPP and not postponed (possibly for a half-century or more). Regrettably, today only Russia is in a position to offer such fully integrated services.[10] At any rate, it would be safe and good management practice for any new consumer state to initiate an R&D program for the final disposal of spent fuel and HLW as soon as a decision to construct a first NPP has been made.

In order not to accumulate quantities of spent fuel containing plutonium in each and every country operating NPPs, would there be some merit in considering regional multinational spent fuel storage facilities? In other words, would such a facility:

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

To answer these questions, one should consider three subcases depending on whether the spent fuel storage facility:

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

Today, the states that have accumulated the largest quantity of spent fuel and HLW are the United States, France, Russia, Germany, Japan, South Korea, Taiwan-China, Canada, the United Kingdom, and Sweden. Among these states, Russia, France, the United Kingdom, and Japan are storing spent fuel at their national reprocessing facilities in addition to storing spent fuel on-site at their NPPs. Sweden has built a stand-alone centralized storage pond 30 meters below the ground surface (the so-called CLAB, designed to provide storage capacity for 30 to 40 years before final disposal) located near the Oskarshamn NPP. Germany has constructed interim

storage plants for spent fuel in large casks at Gorleben (lower Saxony) that were eventually supposed to be disposed of on-site in a deep salt geological repository, as well as at Ahaus (Nordhein-Westfalen). The German government has suspended shipments of spent fuel casks to Gorleben and Ahaus due to intense public opposition. If the Swedish exception can attest to the lack of attractiveness of stand-alone centralized spent fuel storage facilities, then the construction of a regional multinational storage facility should not be anticipated anytime soon, notwithstanding its intrinsic nonproliferation and security merits.

Constructing a new reprocessing plant cannot be economically competitive unless it has a large annual capacity (for example, between 800 and 1,000 tons of heavy metals) and guaranteed contracts with customers to fill that capacity over a long period of time (20 years or more). Reprocessing spent fuel should not take place as long as the owner of the fuel is not in a position to recycle the resulting plutonium as MOX fuel (UO_2-PuO_2) or otherwise sell it for recycling by another electrical utility.

States with significant experience with light water reactors should consider the merits of burning in their reactors excess civilian (weapons-grade) plutonium (such as the plutonium stored in the United Kingdom) or plutonium originating from dismantled nuclear warheads. In order for the resulting MOX fuel assemblies to be competitive with low-enriched fuel elements, it is likely that the owner of the excess plutonium will have to pay the electrical utility to accept and recycle it in its NPPs. In other words, the excess plutonium takes on a negative economic value.[11]

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

Yet most national laws (except in Russia) are presently based on the principle that every country needs to store and dispose of its own nuclear waste within its national borders. The "All In My Backyard" (AIMBY) principle, which is currently deemed to be politically correct, is in fact another version of the NIMBY syndrome, defined as outright opposition to the importation of foreign waste for long-term storage and disposal in one's own country. This widespread policy should be reconsidered and modified as appropriate since it is counterproductive from an economic, safety, and nonproliferation point of view.

Whether dealing with the front- or back-end of the nuclear fuel cycle, it is important to identify the characteristics of a multinational facility that would make it most valuable from a nonproliferation and security perspective. When dealing with sensitive fuel cycle facilities, such as enrichment and reprocessing plants, a first necessary condition is to have at least three partners (or shareholders), none of whom has a majority stake. A joint venture between two neighboring states with the host country holding a majority share would likely not add much benefit from a nonproliferation point of view. However, for a spent fuel storage or disposal facility (as is the case of

shared NPPs) such a condition would not be necessary. In order not to spread sensitive enrichment technologies, multinational facilities should be established on the basis of a "black box" for shareholders who are not technology holders.

As a prerequisite, the IAEA should also confirm that the six conditions mentioned on pages 8 and 9 have been met by the host country and the relevant facility. Foreign partners will have to address the sensitive issue of how to cope with cases in which the host country is either found in non-compliance with its safeguards obligations or withdraws from the NPT.

As exemplified by North Korea and Iran, one of the greatest difficulties in deterring states from violating their nonproliferation undertakings is their hope that, for geopolitical or economic reasons, at least one of the five veto-wielding members of the UN Security Council will oppose the adoption of effective sanctions. It is therefore urgent to strengthen the IAEA's verification authority and improve the likelihood of prompt and firm Security Council action when a state found in non-compliance with its IAEA safeguards or NPT obligations does not fully cooperate with the Agency in promptly resolving any outstanding issues.

To guarantee a timely Security Council reaction in cases of non-compliance, the Security Council should adopt a generic (that is, not state-specific) resolution, under Chapter VII of the UN Charter, based on the model contained in Annex I of my recent Carnegie Paper on "Concrete Steps to Improve the Nonproliferation Regime."[12] Such a generic resolution would establish, independently of any specific case, that when a state is found by the IAEA to be in non-compliance with its safeguards agreement, the following steps would automatically take effect:

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1. The Security Council would, upon request by the IAEA, automatically adopt a *specific* resolution under Chapter VII requiring that state to grant the IAEA extended access rights, set out in a model Temporary Complementary Protocol (TCP).[13]
2. If the non-compliant state does not promptly and fully implement the TCP the Security Council would then adopt a second specific resolution requiring the state to suspend immediately all sensitive nuclear fuel cycle-related activities.
3. In case of further refusal to comply, the Security Council would adopt a third Chapter VII resolution calling on all states to suspend forthwith the supply of any military equipment and cooperation with the non-compliant state as long as it remains in non-compliance with Security Council and IAEA resolutions.

These concrete steps by the Security Council would provide a strong disincentive for states to defy legally binding Security Council resolutions without triggering sanctions that could impact the well-being of ordinary citizens.

Are there enrichment or reprocessing technology holders interested in establishing a multinational facility in a NNWS that does not already operate such a plant? My impression is that the true answer is no, unless there is a strong economic advantage to do so. The German government has been encouraged by international interest in its proposed Multilateral Enrichment Sanctuary Project.[14] I doubt, however, that a technology holder like Urenco would find much commercial interest to participate in

such a complex project,[15] even if the company would not likely admit this in public to avoid criticism from German authorities.

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

The only NNWS that appears to be interested in constructing a new spent fuel reprocessing plant is South Korea. The problem is that, according to the "Joint Declaration of South and North Korea on the Denuclearization of the Korean Peninsula," which entered into force on February 19, 1992, it was agreed that "South and North Korea shall not possess nuclear reprocessing and uranium enrichment facilities," and that "South and North Korea shall not test, manufacture, produce, receive, possess, store, deploy or use nuclear weapons." Now that North Korea has twice tested nuclear devices,[16] and, in April 2009, expelled IAEA inspectors tasked to monitor and verify the shutdown status of Yongbyon's facilities, it is uncertain how long South Korea will continue to feel bound by the 1992 Joint Declaration.

The issue is complicated by the fact that South Korea wishes to recover nuclear material contained in spent fuel through a process called "pyroprocessing," to create new fuel that can be used in next generation fast reactors. Some U.S. officials support the South Korean point of view that "pyroprocessing is not reprocessing because it does not produce pure plutonium."[17] Under its current nuclear cooperation agreement with the United States, which remains in force until 2014, South Korea cannot reprocess spent fuel without first obtaining U.S. approval. To make the project more acceptable internationally, South Korea has unofficially indicated its willingness to consider the construction of the pyroprocessing plant on its territory under a multinational arrangement. Whether such a gesture would satisfy potential proliferation concerns remains to be seen.

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

Kazakhstan has taken a 10 percent participation in the Russian International Uranium Enrichment Center (IUEC) at Angarsk. Ukraine and Armenia have indicated that they intend to take similar shares.[18] It should be stressed that the IUEC is not, as its name suggests, an enrichment plant, but rather a LEU storage facility located on the site of the Angarsk Electrolysis Chemical Complex (AECC), which operates the enrichment plant. Participants in the IUEC (of which Russia will retain a majority share) will have guaranteed access to the uranium capacity of the AECC. It is not clear why a country like Armenia – which has only one NPP[19] in operation and no large uranium resources – is interested in participating in the IUEC, unless the venture is part of a broader commercial and financial agreement with Russia.

The cases of Iran and Brazil also bear mentioning. There have been some indi-

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

Conversely, it is quite understandable that Iran has so far shown limited interest in becoming a partner in the IUEC at Angarsk. Iran might fear that participating in such a project would increase the international pressure for it to suspend or even abandon its domestic enrichment program. Iran has also indirectly been a shareholder[20] of the large EURODIF enrichment plant in France since the late 1970s but has never been able to obtain LEU from that facility. This highlights that the real issue at stake is the guarantee to obtain necessary export licenses not only from the state where the enrichment takes place, but also from the country where the fuel fabrication plant is located (if it is not the same).

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

More recently, Brazil has constructed the Resende Nuclear Fuel Facility, a centrifuge enrichment plant managed by Nuclear Industries of Brazil (INB) and the Brazilian Navy. The capacity of the facility will increase progressively and is expected, by 2015, to cover the needs of the country's two NPPs, Angra 1 and 2. The enriched uranium that will be necessary to fuel Brazil's nuclear propulsion submarines will likely be produced in another enrichment facility.[21]

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

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

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

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

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

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

Above all, it is urgent to strengthen the IAEA's verification authority and improve the likelihood of prompt and firm UN Security Council action when a state is found to be in non-compliance with its IAEA safeguards or NPT obligations and does not fully cooperate with the Agency in promptly resolving any outstanding issue. Rapid implementation of the concrete steps and the fuel supply and spent fuel management measures described in this essay is crucial for the future success of the NPT regime.[22]

ENDNOTES

[1] The present paper was originally drafted in April 2009.

[2] Pierre Goldschmidt, "Mechanisms to Increase Nuclear Fuel Supply Guarantees," paper presented at the Carnegie International Nonproliferation Conference, November 7 – 8, 2005, http://www.carnegieendowment.org/static/npp/2005conference/presentations/Goldschmidt_fuel_supply.pdf.

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

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

[5] This mechanism is described in the February 23, 2009, report (GOV/INF/2009/1) to IAEA member states and is reproduced in a document tabled on May 6 at the NPT Preparatory Committee for the 2010 Review Conference (NPT/CONF.2010/PC.III/WP.25).

[6] Cf. footnote 1 in IAEA, GOV/INF/2007/11.

[7] No one has suggested that any NPT state should forgo its right to develop national fuel cycle capabilities, but rather, that additional fuel supply guarantees would be made available to those consumer states *choosing* not to exercise their right to enrich uranium domestically.

[8] IAEA GOV/2008/14, The Safeguards Implementation Report for 2007, section 13 (May 7, 2008).

[9] IAEA GOV/2009/31.

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

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

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

[13] Ibid., Annex I.

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

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

[16] These tests took place on October 9, 2006, and May 25, 2009.

[17] Miles A. Pomper, "Concerns Raised as South Korea Joins GNEP," *Arms Control Today* (January/February 2008), http://www.armscontrol.org/act/2008_01-02/gnep.

[18] South Korea and Mongolia have also reportedly expressed interest in joining the project.

[19] The Metsamor NPP is a VVER-440 Model V-230 reactor of 408 MWe and has been in operation since 1980. Armenia envisages the future construction of a new reactor of 1,000 to 1,200 MWe.

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

[21] According to Mark Hibbs: "Plans by the navy to enrich uranium for submarine reactor fuel . . . call for enrichment to take place at a dedicated facility . . . not at [the] existing Resende plant. The Resende plant . . . is subject to a trilateral safeguards agreement that limits the level of enrichment to 5% U-235. The reactor fuel required by the navy must be enriched to perhaps close to 10%." Mark Hibbs, "Brazil, Verification Agencies Aim for Naval Fuel Safeguards Negotiations," *Nuclear Fuel* 34 (5) (2009): 7.

[22] I am grateful to Nima Gerami for his comments on earlier drafts of this paper. All errors, however, are my own.

George Perkovich

Global implications of the U.S.-India deal

On July 18, 2005, President George W. Bush and Indian Prime Minister Manmohan Singh announced their desire to change a series of national laws and international rules that the United States had helped create over a 30-year period to strengthen the nonproliferation regime. These rules were meant to deny nuclear cooperation with India and other states that refused either to sign the Nuclear Non-Proliferation Treaty (NPT) or to put all of their nuclear facilities under international safeguards. Between 2005 and September 2008, Bush and Singh personally invested large amounts of political capital to win all the national and international approvals required to accommodate India's request for nuclear cooperation. What began as an obscure, albeit revolutionary, quest by a handful of driven individuals in Washington and New Delhi, ended up as an agreement by the 45 members of the Nuclear Suppliers Group (NSG) to exempt India from nonproliferation rules that are supposed to remain applicable to all other states.

The making and enforcing of international rules is frequently quixotic. Making rules is often tedious and compromising, while their enforcement is often absent or feckless. The nuclear nonproliferation regime has suffered these afflictions. However, considering that the ambition is to regulate the most powerful technology and material known to humankind, the rules that have grown around the NPT since 1968 have been remarkably successful. The nonproliferation regime is a key structure of the nuclear order that most people in the world would rather not live without. Some wish that this nuclear order would more strongly incline toward the abolition of nuclear weapons, or would more actively promote distribution of nuclear energy. Others wish that it would concentrate more effectively on stopping proliferation. Few want the disorder that would follow a collapse of the bargains on which the current system of rules depends. Thus many observers and governments fear that the NSG-India nuclear deal is a bad portent: it may signal corrosion of the rules-based nuclear order.

The nuclear nonproliferation regime's success owes largely to the fact that the two leaders of the bipolar world cooperated in drafting and negotiating the NPT in the mid-1960s. Even as they competed everywhere and built arsenals capable of destroying life on earth many times over,

the superpowers worked closely to frame rules to prevent additional actors from acquiring nuclear weapons. Washington and Moscow persuaded key states to sign the NPT, in part by pledging that no states beyond the United States, Russia, China, France, and the United Kingdom would acquire nuclear weapons. The superpowers also guaranteed others against nuclear threats; Germany, Italy, Japan, and Australia were among those persuaded to sign the NPT on this basis. As the bipolar order collapsed with the Soviet Union in the early 1990s, the United States and Russia continued to cooperate to induce Belarus, Kazakhstan, and Ukraine to transfer the nuclear weapons on their territory to Russia. Argentina, Brazil, and South Africa joined the NPT as part of national strategies to integrate with the global nuclear order. The impression grew that the Cold War system would be replaced by a globalized, rule-based order founded on market economics, democratization, and gradual nuclear disarmament.

To states not allied with Washington, the 1990s was a period when the United States, unbalanced in power by the fall of the Soviet Union, became nearly hegemonic. In hegemonic systems, rulemaking and enforcing tend to depend on the leader. Theoretically, a benign hegemon can induce others to subscribe to rules by reassuring them that advantages will be mutual and disputes will be resolved fairly. Yet the virtue of a hegemon is in the eyes of the beholder: other states in the system may see self-dealing, if not malice, in the hegemon's preferences. Historically, there is a natural tendency from others to try and balance the hegemon. By the late-1990s, Russia and China spoke openly of preferring a multipolar system. India, Brazil, and South Africa also developed intentions and capabilities to rise as major powers. Iran, Iraq, and North Korea increasingly sought to deter intervention by the United States now that there was no competing superpower with which they could align for protection. States most wary of the U.S.-led order – Iran, Iraq, North Korea, Libya, and Syria – sought to defeat the nonproliferation system and acquire nuclear weapons capabilities, sometimes through cooperation among themselves. Terrorist groups scrambled for capabilities to threaten the United States and other states that followed its lead, al Qaeda being the prime example.

Global implications of the U.S.-India deal

Each of these tendencies was exacerbated by the election of George W. Bush in 2000 and the 9/11 attacks on the United States. The new U.S. administration explicitly sought to buttress and assert U.S. hegemony, "dissuade" the emergence of a "peer competitor," and remove or neuter undemocratic regimes hostile to the U.S.-led international order.[1] The administration wanted to strengthen the terms and enforcement of rules that constrained others while leaving U.S. power unchecked. States that wanted to reduce the relative power of the United States and gain influence for themselves were inclined to resist.

The multiple effects of these competing interests and trends cannot be elaborated here. In short, the nonproliferation regime was being stressed; the United States, the actor most needed to rally others to strengthen the regime, instead spoke and acted in ways that undermined cooperation rather than encouraged it. It is in this context that the implications of the nuclear deal with India are explored here.

The U.S.-India nuclear deal and its transformation into the NSG-India nu-

clear deal involved making and unmaking international rules. By exempting India from rules, the deal amounted to selective non-enforcement. At the same time, the United States, appropriately, was emphasizing the need for more robust enforcement of international rules. Less powerful states, also appropriately, were insisting that the bargains underlying the nonproliferation regime should be enforced fairly. To many, fairness means universal enforcement. From this perspective, the importance of the nuclear deal with India has less to do with India than with the capitals of the states that make and enforce the rules, particularly the United States. India sought what its leaders wanted. It was up to others to protect the global public good that derives from the rule-based nuclear order.

It is beyond the scope of this essay to narrate the day-to-day story of how the United States and India navigated their own political processes and those of the International Atomic Energy Agency (IAEA) and the NSG to bring the deal to fruition. The final terms exempted suppliers from previous restrictions on nuclear cooperation with India, enabling them to sell reactors and related components, fuel, software, and other dual-use equipment. In return, India agreed to declare publicly which of its current and future nuclear facilities are civilian and which are military, and to put the former under the most advanced international safeguards, called the Additional Protocol. Further, India agreed to institute effective export control systems consistent with the NSG and to refrain from transferring enrichment and reprocessing technologies to states that do not now have them. New Delhi also pledged to continue its "unilateral moratorium" on nuclear testing.

The following beliefs or assumptions drove the nuclear deal:

- Balance-of-power competition supersedes rule-based international regimes in practice and, in some cases, moral-political principle;
- The rule-based nonproliferation regime, with its underlying premise that all states should be treated equally and that disparity in treatment should be the result of balanced bargains, fails to eliminate the threats posed by the most dangerous actors but constrains the power of benign actors such as the United States and India;
- China is the only rising power that could have the capability and intention to rival U.S. hegemony. Therefore a top priority should be to dissuade China from attempting to rival the United States militarily, including by ensuring that China's neighbors share U.S. interests in balancing Chinese power; and
- India, a rapidly growing, established democracy with an increasingly important diaspora, should be elevated in international rank and drawn into closer partnership with the United States.

Not *all* of the key figures in the Bush administration shared *all* of these strategic assumptions. But these basic premises were held by enough high-level officials to create an environment in which the U.S.-India nuclear deal could gestate. As Ashley Tellis recalls, "The administration's own antipathy to nuclear arms control agreements such as the Comprehensive Test Ban Treaty and the Fissile Material Cut-off Treaty . . . coupled with its strong expectation of an eventual renewal of great-power competition, allowed both realist and neoconservative

factions within the administration to take a more relaxed view of New Delhi's emerging nuclear capabilities."[2]

Realists and neoconservatives believed that the rule-based nonproliferation regime often fails to deter or reverse the illicit nuclear activities of dangerous actors. Rules tend to constrain the military power and economic activities of unthreatening law-abiding actors, including the United States, while being exploited by the ones that most need to be checked. Therefore it makes little sense to expend time, leadership, and potential military advantage in negotiating better rules and pursuing enforcement through unwieldy international bodies.

Some conservatives, including John Bolton and Robert Joseph, privately dissented from the idea that the remedy for inadequate rules was to stop enforcing them against India. But these nonproliferation specialists did not sufficiently appreciate the administration's grand strategy: to place a state's friendliness toward the United States and, where applicable, that state's democratic character, above specific behaviors such as nuclear policy. The friendliness of India toward the United States was more important than its nuclear policy, period, especially insofar as it could help constrain China's future power. The deal's champions – Ambassador Robert Blackwill, State Department counselor Phillip Zelikow, advisor Ashley Tellis, Secretary of State Condoleezza Rice, and National Security Advisor Stephen Hadley – persuaded the president to issue internal guidance to negotiators that terms of the deal should not constrain India's strategic capabilities. As discussed below, this practically precluded insistence that India accept nonproliferation limitations on its production of fissile materials for military purposes or that it sign the Comprehensive Test Ban Treaty (CTBT), among other things.

Champions of the nuclear initiative toward India also argued that sizable U.S. concessions would reap nonproliferation gains, not losses. India would now strengthen its nuclear export controls and resist future temptation to sell sensitive nuclear technology or know-how to states or individuals with dubious intentions and records. India was, in fact, already obligated by UN Security Council Resolution 1540 to maintain the tightest possible export controls, and India's own self-proclaimed reputation as a responsible steward of nuclear technology committed it to exemplary nuclear practices. Thus, it could seem strange and unnecessary to bribe India with drastic changes in U.S. and international nonproliferation rules to do what responsible nuclear actors should do in any case. To this claim, administration grand strategists countered, "Virtue is not its own reward."[3]

France and Russia were entirely supportive of loosening restrictions on nuclear commerce with India, but the initiative was Washington's, developed without consulting Paris and Moscow even though both were known to be sympathetic. Administration leaders judged that proceeding through discussions and negotiations with the broader international community would drastically slow the process and dilute the results. Similar concerns motivated these individuals to limit Washington's interagency process of shaping the proposed deal.

The "virtuous" states in the nuclear nonproliferation regime, and most of the regime's devotees around the world, feared that rewarding a state that was outside of the NPT and possessed nuclear weapons would weaken the nuclear

order. By granting India full international nuclear cooperation heretofore reserved only for states that allow international safeguarding of all their nuclear facilities and materials, the deal gave India benefits that the non-nuclear-armed states felt devalued their virtue.

Concern over devaluing the nuclear abstinence of others could have been mitigated if the United States had extracted commitments from India to sign the CTBT and to end production of fissile materials for nuclear weapons. These two arms control measures had long been atop the international community's benchmarks for ending the nuclear arms race and facilitating nuclear disarmament. If the offer of nuclear cooperation could have induced India to take these steps (which it otherwise was unwilling to do), then a deal could have been seen as a worthwhile advance toward the ultimate goal of nuclear disarmament, albeit imperfect. This would be especially important to non-nuclear-weapons states, the ones that felt most devalued by the move to exempt India from the rules that they lived by.

Many factors will determine India's future actions, of course, but it is possible that the nuclear deal will make India less, rather than more likely to join the CTBT and end fissile material production for weapons. The nuclear deal has encouraged India to develop new plutonium separation capabilities for military purposes, especially as, under the deal, India has declared that its Fast Breeder Reactor will be part of its weapons program. India already had perceived a need for additional separation capabilities. However, the explicit separation of civilian from military facilities provides the Indian government domestic political cover to invest in new plants. New Delhi can say that this spending is a necessary consequence of receiving the civilian benefits of the deal. The question then arises whether India will in the foreseeable future agree to a moratorium or a treaty that would curtail the operations of newly built and paid-for military plutonium separation capabilities.

In negotiating the deal, the U.S. and Indian governments pointed to India's support of a Fissile Material Cutoff Treaty (FMCT) as evidence of the nonproliferation benefits that would come from cooperating with New Delhi. This was cynical even by standards of diplomacy. Both states knew that a FMCT would take years to negotiate, and that their own differences over the prospective treaty's terms would slow, if not block, agreement. (For example, the Bush administration proposed a treaty without verification, while India insisted that verification be included.)

Focusing on a FMCT obscures an immediate step that each nuclear-armed state can take to strengthen the global nuclear order. The United States, Russia, France, the United Kingdom, and (less certainly) China have all unilaterally ceased producing fissile materials for weapons. Were India, Pakistan, and Israel to join these moratoria, the world, for the first time since 1942, would be free of nuclear-weapons fuel production. These states could add verification provisions through subsequent treaty negotiations. In the meantime, they could rely on national means of monitoring each other's compliance with the moratorium. By ignoring the moratorium route, and giving lip service to prospects of negotiating a treaty, the United States and India further undermined the cause of nonproliferation and disarmament, as did all other states that later became complicit in the deal.

Of course, a decision by India to stop military fissile material production will depend on Sino-Indian relations and Beijing's willingness to limit the size and net capability of the nuclear arsenal it could deploy against India. Yet neither the Bush administration nor India sought to engage Beijing in exploring whether and how to limit nuclear competition.

The deal also has "granted" India the "right" to reprocess, for military purposes, the spent fuel from the eight reactors that are not designated as civilian. These reactors previously had been assumed to be power-generation plants, not sources of plutonium for weapons. To the extent that the nuclear deal gives India access to foreign-supplied fuel for civilian reactors, India could use its heretofore scarce domestic supplies of reactor fuel to increase production of plutonium in military reactors – a potential already noted by Pakistan. Concerns over such a scenario are aroused by memories that India extracted the plutonium for its 1974 nuclear explosion from the CIRUS research reactor that the United States and Canada supplied to it for exclusively peaceful purposes. (The CIRUS reactor is shown on the inside front cover of this issue.) Islamabad sees the deal as adding to the threats it faces from India, and in turn sees a need to increase its own capacity to produce weapons-usable fissile materials. Pakistan, with Chinese assistance, is building a third plutonium production reactor at Khushab.[4] (The reactor was planned before the U.S.-India nuclear deal.) Like India, Pakistan could be more reluctant to abandon the "benefits" of new investments in military fissile material production capabilities by negotiating a ban on such production. Pakistan's pique over the nuclear deal and the potential boost it could give to India's fissile material production facilities could make it more inclined to "punish" the United States by holding out against a ban, even though by agreeing to end production of more bomb material, and putting pressure on India to follow suit, Pakistan would negate India's increased potential to catch up with it in this area.

The nuclear deal's effects on the CTBT could be more complicated. India, Pakistan, and China are among the 44 states that must ratify the treaty for it to enter into force. All three states have adopted moratoria on nuclear testing. China has signed the treaty but, like the United States, has not ratified it; India and Pakistan have not signed. Since the nuclear tests of 1998, some Indian strategic experts and former military leaders have opined that India cannot have confidence in its thermonuclear-weapon capability without more tests.

The nuclear deal lessens the probability and potential potency of sanctions against India if it were to resume testing. It could be perceived that each step leading to the NSG's exemption for India weakened signals for India not to test. The Hyde Act, which is supposed to guide U.S. policy, declares that the United States must halt all U.S. nuclear exports if India resumes testing. The U.S.-India Nuclear Cooperation Agreement, negotiated after the Hyde Act, allows termination for any reason, after one year's notice, but it does not specify or require sanctions for testing. The NSG declared that participating governments will maintain contact to consider matters related to implementation of the agreement, suggesting that if India tested, members would meet to consider possible penalties.

In the meantime, the nuclear deal enables India immediately to import fuel and sign reactor construction contracts with foreign suppliers. Facing a severe

shortage of uranium fuel, India negotiated an agreement with Russia in February 2009 to import 2,000 metric tons of uranium for its current reactors, and to buy six additional reactors from Russia. India reportedly is negotiating with France for supply of 300 metric tons of uranium per year.[5] India also has made a civil nuclear cooperation agreement with uranium-rich Kazakhstan that includes provisions to deliver natural uranium to India.[6]

Thanks to these fuel imports, India in a few years would be in a much stronger position to withstand consequences of testing than it would have been without a deal. Without the deal, India would face a worse fuel shortage, one that has already sharply reduced electricity supply from its civilian reactors. With the deal, India can both stockpile imported fuel for its civilian reactors and dedicate its domestically produced fuel to military purposes. If India were to test a nuclear device after several years of receiving fuel imports, it would be able to withstand interruption of foreign fuel supplies, especially if in the intervening period India increases its own uranium mining operations. Moreover, if the nuclear deal results in contracts with France, Russia, and the United States to build new civilian reactors in India, those suppliers would find significant self-interest in rejecting national or UN Security Council sanctions against India for resuming nuclear tests.

Of course, were the United States and China to ratify the CTBT, they could create an international political dynamic that could motivate India to sign and ratify the treaty without resuming testing. India is not committed to do so, and the nuclear deal strengthens its capacity to hold out. But if other states, particularly non-nuclear-weapons states in Asia, Africa, and South America were to urge India to demonstrate responsibility for strengthening the global nuclear order by joining all other nuclear-armed states in a test ban, India's interest in being recognized as a global leader could lead it to cooperate. If such diplomacy could be framed more broadly as a movement toward nuclear disarmament, which India has long championed, the Congress Party could be motivated to seek Indian cooperation. Indian politics will always resist heavy-handed pressure, but the gains India has made through the nuclear deal, plus new global movement toward nuclear disarmament, could make India amenable to respectful suasion.

Other states lack the power, expertise, and drive to substitute for U.S. leadership. The nonproliferation regime cannot be strengthened without the cooperation of the United States, Russia, China, and the European Union. By proceeding more or less unilaterally and downgrading nonproliferation objectives, the United States disempowered other states, particularly those that did not share many or all of its strategic objectives and assumptions. If others could not participate early with the United States in developing the terms under which nonproliferation constraints would be lifted, they would naturally feel less ownership and responsibility for the nonproliferation regime, whose rules were being changed. The sense that the world's strongest power was prepared to make exceptions based on its own prerogative undermines the perceived legitimacy of both the leader and the regime.

Officials and opinion shapers in more than a dozen countries have complained that the United States was changing the rules to fit its definitions of "friends" and "foes." How could others have con-

fidence in a rules-based system and U.S. leadership if the rules were to be changed at Washington's whim, without genuine consultation with other stakeholders before decisions were made? Many sensed that U.S. commercial interests were motivating the changes, making the deal a matter of self-aggrandizement from which two other nuclear-weapons states, France and Russia, were only too happy to benefit as well.

To be sure, each NSG member state could have blocked the deal, given that the NSG operates by consensus. Yet once Washington and New Delhi established the basic terms, other states – including many that did not like the terms – went along because they valued good and profitable relationships with the United States and India more than they valued nonproliferation objectives. Had Washington approached these states at the beginning of the initiative to seek a collective approach to India, the others probably would have pushed for stronger nonproliferation terms. By reversing the order – presenting an initiative with great momentum already behind it before seeking consultations – the United States exposed that other states generally lack the determination and ability to privilege public goods over narrower interests.

The reality that the United States, France, and Russia put mercantile nuclear interests above the integrity of the nonproliferation regime also has negative consequences. The major nuclear exporters sought to favor India with exemption from the rules because India offers a potentially large market for their goods and services (whereas Pakistan and Israel, for example, do not). The United States, France, and Russia are not only leading nuclear-weapons states, they are also permanent members of the UN Security Council, bearing ultimate responsibility to enforce the NPT. To the degree that their integrity as principal authors and enforcers of nonproliferation rules can be questioned due to their special and narrow interests as nuclear exporters, the legitimacy of the overall nuclear order is weakened.

Many other NSG states perceived this mercantile motivation; some had commercial interests of their own. Germany, for example, is not a major nuclear exporter (though Siemens and other German firms do export components), but it supported the NSG-India deal in large part to prevent India from disfavoring German firms in Indian state procurement. Other states that wish to sell conventional weapons to India, such as Sweden, went along as well. Similar economic interests trickled down to smaller NSG states that otherwise judged the nuclear deal to be highly damaging of the nonproliferation regime. Discussions with many diplomats and parliamentarians from smaller NSG states revealed that their complicity in the end was determined by reluctance from their leaders and national businesses to suffer political-economic penalties from the United States, France, Russia, and India. These individuals expressed that if an influential state such as Germany would have blocked or sought tougher terms in the deal, their governments would readily have stood with Germany.

The vital point here is that the profit motive can seriously degrade the NSG, which has been the world's only cartel designed to foil profit-taking that could undermine global nuclear security. This cartel was formed in recognition that the dangers of nuclear proliferation should outweigh the marginal gains that nuclear commerce with three states outside the NPT might bring.

The integrity of the IAEA did not escape damage from the India deal either.

Director General Mohamed ElBaradei welcomed the prospective deal the day it was announced, *before* any of its terms had been negotiated: for example, how much of the Indian nuclear program would be put under safeguards, what sort of safeguards would be accepted by India, what parallel nonproliferation and disarmament obligations India would undertake. ElBaradei's early and apparently unconditional imprimatur effectively preempted international efforts to strengthen the deal's nonproliferation terms. Then, in 2008, when India negotiated safeguards with the IAEA, ElBaradei seemed to signal that the Agency should agree to terms less strong than some professionals in the safeguards division thought appropriate.[7]

Unconstructive actors can easily try to exploit the selectivity of rule-making and enforcement. A diplomat from the Democratic People's Republic of Korea (DPRK) declared in July 2008 that North Korea would insist that before it completes disarmament, the nuclear plant promised to it under the 1994 Agreed Framework must begin to operate.[8] The diplomat was asked whether any U.S. official had told the DPRK that this would be the order of things, inasmuch as pursuing such cooperation before the DPRK disarmed would contradict core principles of the nonproliferation regime. He replied, "You did it for India." The American said that North Korea was not India; there are many distinctions between the two. The North Korean said, "The point is not about North Korea. It is that when the U.S. decides that it wants to treat another state differently, it can do so. You decided India was your friend, so you did what it wanted. That's the issue."

Some Iranians make a similar point in private. They note not only how the United States accommodated India, but also how other countries went along with it because India is a major country and a big economic market. They believe, or hope, that the international community will accept Iran's ongoing enrichment program and drop sanctions because Iran is important in the way that India is.

Less recalcitrant states may also have drawn unhelpful lessons from the NSG-India deal. The IAEA Director General and others have long urged all states to implement the Additional Protocol, which gives inspectors enhanced ability to detect violations of safeguards and other nonproliferation obligations. A number of states with ambitions to develop advanced nuclear programs have not yet done so. At least one such state put off adoption of the Additional Protocol in reaction to the U.S.-India deal's announcement, due to its leadership's dismay that a state (India) that had refused to join the NPT and had resisted numerous nonproliferation and disarmament measures was now being rewarded on the whim of the same country (the United States) that purported to be the steward of nonproliferation rules.[9]

Of course, the perception of diminished integrity and determination can be reversed. If and when the next case of a state breaching its safeguards obligations and defying demands for corrective measures arises, the leading nuclear powers and the NSG could hold firm and put nonproliferation interests above economic interests and political favortism. Iran may be such a case, and it shows how the India deal exacerbates what is already an extremely difficult enforcement challenge. Some enforcers, perhaps including China, rationalize putting national economic interests above nonproliferation by recalling how

the United States (and others) have done so with India. It becomes tempting, then, to think that things will be different in the *next* next case: *after* Iran, "we" will really stand firm. But when the next case arises, and if it involves a state of economic and/or political importance to Security Council members and major NSG states, the temptation to say, "Well, we did it for India and for Iran, why not for X?" will arise once again.

The nonproliferation regime will be challenged in yet another way as a result of the India deal. Many NPT parties and observers believe that the 2010 Review Conference will be exceptionally important in restoring the regime's credibility and strengthening its terms and states' commitments to enforce compliance with them. One hundred forty-six states-parties to the NPT are not members of the NSG. They did not have a vote in approving the India deal. Some have no strong opinion about it or objection to it. Others, however, disagree with the way the deal was pursued and/or the terms under which it was concluded. As one diplomat put it recently:

> Some NSG countries felt very strong pressure to support the India deal, even though it was not in accordance with the NPT. Some are concerned that this agreement could be proliferated to Pakistan. There is the possibility and the temptation to use the NPT Review Conference to address this question. Not to undo or revisit the India agreement, but to express displeasure that it was done and over the way it was done.[10]

When the NSG assented to exempt India from restrictions on nuclear cooperation, the deal was done. The challenge now is to understand the implications and to maximize the positive and minimize the negative while renovating the global nuclear order. None of the world's major players is innocent. Even as the United States – along with France, Russia, and India – is most responsible for the situation that now exists, all members of the NSG should feel an obligation to cooperate in the refurbishment project.

With Pakistan particularly in mind, the NSG should consider establishing criteria under which nuclear cooperation could be made available to the remaining two states that never signed the NPT. The right criteria could help motivate Pakistan to take steps that are in the world's security interests. To attenuate perceptions of unfairness among Pakistanis and perhaps others (and not exacerbate them), criteria should be those that India would have met had they been applied before the nuclear deal was made. Establishing criteria could also strengthen the case against nuclear cooperation with Pakistan that others might undertake more to even the score with India (and the United States) than to ensure that Pakistan's development needs are met and its nonproliferation bona fides strengthened.

NSG members and the IAEA Board of Governors should clarify why the India deal is not a precedent for treatment of states that violate their safeguards or other NPT-related obligations. At a minimum, NSG members could resolve not to continue or extend nuclear cooperation with states that are not compliant with their safeguards obligations to the IAEA, that remove facilities or materials from IAEA safeguards, that make nuclear threats against non-nuclear-weapons states that are compliant with NPT obligations, that do not recognize the existence of other states, and that are complicit with terrorist organizations. India meets these criteria whereas Iran and

the DPRK are the most obvious states that do not; they and other states with interests in developing latent nuclear weapons options need to hear this clarification. The point is that strong, preventive diplomacy should affirm that enforcement of nonproliferation norms and rules will not be slackened regarding states that might consider nuclear technology acquisition as a hedge for military applications in the future.

To further dissuade states from calculating that nuclear suppliers would eventually accommodate them if they withdrew from the NPT, the UN Security Council should take preventive action. As proposed by Pierre Goldschmidt, former Deputy Director General of the IAEA for Safeguards, the UN Security Council should:

> Adopt a generic and legally binding resolution stating that if a state withdraws from the NPT (an undisputed right under Article X) after being found by the IAEA to be in non-compliance with its safeguards undertakings, then such withdrawal constitutes a threat to international peace and security (as defined under Article 39 of the UN Charter). This generic resolution should also provide that, under these circumstances, all materials and equipment made available to such a state or resulting from the assistance provided to it under a Comprehensive Safeguards Agreement would have to be forthwith removed from that state under IAEA supervision and remain under Agency's Safeguards. This resolution should require that all military cooperation with the withdrawing state be automatically suspended.[11]

Finally, one of the most important correctives necessary after the NSG-India deal is to attenuate perceptions of discrimination and arbitrariness in the making and enforcing of nonproliferation rules. If states and attentive populations feel that this deal began because the United States devalued treaties and rules and wanted to build favor with its new friend India – in part to balance the power of its competitor, China, and in part to enrich U.S. companies – and other states went along with it because India is a big market, then the core principles of fairness necessary to sustain a rule-based system are undermined. Differences in political-economic power will always influence international politics. The point of rule-based systems is to regulate and minimize differences in ways that improve the good of all. Leaders of the system, including the United States, must restore this commitment.

One way to alleviate differences is to reduce the perceived advantage of the nuclear-armed states in terms of prestige and power. A genuine commitment to nuclear disarmament, and steps toward it, is important in this regard. President Obama's April pledge to seek progress toward the elimination of all nuclear weapons can be a basis for inviting Indian leaders, who have made similar commitments, to reciprocate when the United States and other nuclear-armed states take disarmament steps such as ratifying the CTBT, ending production of bomb material, and reducing nuclear arsenals. Ultimately, the only way to end the double standards that threaten to weaken the nuclear order is to eliminate all national nuclear arsenals.

ENDNOTES

[1] The 2001 Nuclear Posture Review introduced "dissuasion" as a purpose of the U.S. nuclear arsenal, meaning that U.S. strategic superiority should remain great enough that no other actor would think it feasible to build forces to compete.

[2] Ashley Tellis, *India as a New Global Power: An Action Agenda for the United States*, Carnegie Endowment Report, July 2005, 13.

[3] The argument that it was wise for the United States to pay India to ensure its responsible behavior appears, among other places, in Ashley Tellis, "Should the U.S. Sell Nuclear Technology to India?", http://yaleglobal.yale.edu/display.article?id=6487. Tellis argues: "India's commendable nonproliferation history, however, is owed entirely to sovereign decisions made by its government, not to its adherence to international agreements. As a result, any unilateral change in the Indian government's policy of strict nonproliferation could pose serious problems for American security. This concern has acquired particular urgency in the post-9/11 era because of the incredibly sophisticated capabilities present in India today and because India remains at the cutting edge of research and development activities in new fuel cycle technologies. Bringing New Delhi into the global nonproliferation regime through a lasting bilateral agreement that defines clearly enforceable benefits and obligations, therefore, not only strengthens American efforts to stem further proliferation but also enhances U.S. national security."

[4] http://www.isis-online.org/publications/southasia/ThirdKhushabReactor.pdf.

[5] Sunil Saraf and Mark Hibbs, "Russia to supply more reactors to India, bringing total to 12," *Nucleonics Week*, December 18, 2008.

[6] http://www.world-nuclear-news.org/newsarticle.aspx?id=24507.

[7] The preamble of the IAEA agreement with India contains provisions that suggest safeguards in India would not be in perpetuity.

[8] Discussion with North Korean diplomat, July 23, 2008.

[9] Discussion with knowledgeable official, May 2, 2009.

[10] Discussion with Norwegian diplomat, December 16, 2008.

[11] Pierre Goldschmidt, "Strengthening the Non-proliferation Regime," paper for the 7th ROK-UN Joint Conference on Disarmament, November 24–26, 2008, http://www.carnegieendowment.org/files/goldschmidt_rok_20081124.pdf.

Charles McCombie & Thomas Isaacs

The key role of the back-end in the nuclear fuel cycle

This two-volume special issue of *Dædalus* highlights the challenges associated with the global expansion of nuclear power. The topics covered include environmental impacts, nuclear safety, and the economics of nuclear power production, but the major emphasis is on nonproliferation and security aspects. To develop an understanding of possible problems and their potential solutions in all of these areas, it is necessary to understand the nuclear fuel cycle. Controlling the flow of nuclear materials "from cradle to grave" creates and sustains a safe and secure global nuclear power regime that can help satisfy the world's energy needs and can reduce CO_2 emissions and their associated impacts on climate.

The nuclear fuel cycle consists of multiple technical activities that take place in locations around the world. These activities form a chain, with each having direct impacts on the characteristics of those farther down the line. Accordingly, one objective of this article is to emphasize the holistic and global nature of the fuel cycle. A key challenge to consider is whether there can be opportunities now or in the future to improve the safety, security, economics, environmental impacts, or public acceptance of nuclear power by vertical integration of the chain or by geographical consolidation of the activities.

Each stage of the fuel cycle should be assessed to judge where improvements could increase technical and societal acceptance of a substantial expansion of nuclear power. However, since other articles in this double issue of *Dædalus* on the global nuclear future deal with front-end issues (enrichment, in particular), we concentrate on the back-end stages – namely, storage, reprocessing, and disposal.

To examine the back-end stages of the fuel cycle, it is useful to begin with a brief summary of their current status.

Used fuel storage. All water-cooled reactors store spent nuclear fuel, once it has been unloaded from the reactor, at the reactor site in an underwater pool. Originally it was planned that spent fuel would be shipped off site after some years of cooling; the fuel would then go for reprocessing or direct disposal. In practice, reprocessing is currently carried out in only a few programs, and disposal of spent fuel has not yet taken place. The need for storage has thus increased.

The cooling time before the heat generation of spent fuel has declined to a level suitable for disposal in a geological repository is between 30 and 50 years. There are also other arguments for delaying disposal. For small nuclear programs, many years of operation would be required to accumulate an inventory of spent fuel that justified embarking on an expensive deep repository project. Furthermore, by extending surface storage times for decades, the large expenditures required for implementing such a solution can be postponed.

Today, as pools at reactor sites fill up, spent fuel is increasingly placed in dry storage facilities, which have lower operational costs and which can be implemented in a modular fashion. The casks can be purchased as needed; they do not require a strengthened or strongly shielded building; and they can even be placed on pads in the open air. Most storage facilities are built above ground, although there are exceptions, such as the Swedish CLAB spent fuel pool, situated in a rock cavern some tens of meters below the surface.

Reprocessing. In current reprocessing facilities, used fuel is separated into its three components: uranium and plutonium, which both can be recycled into fresh fuel, and waste containing fission products. The waste is then treated to produce vitrified blocks incorporating most of the highly radioactive materials and other low- and intermediate-level radioactive technological wastes. After conversion and enrichment, the uranium from reprocessing can be reused as fuel, if necessary. The plutonium can either be stored or made directly into mixed oxide (MOX) fuel, in which uranium and plutonium oxides are combined. The vitrified waste is a high-quality standardized product well suited for geological disposal. The technological waste is of much lower activity, and much of it can go to near-surface disposal sites. However, there are problems associated with each output stream.

Plutonium and MOX are unstable in storage because of the buildup of Am241. MOX fuel is more expensive than fresh UO_2 fuel; its specific decay heat is around twice that of UO_2 fuel; and the neutron dose from MOX is about 80 times that from UO_2 fuel. Reprocessed uranium is a "free" by-product, but with modern high burn-up levels, there is less residual U235 and more U236. Moreover, reenrichment increases U232 levels and presents a greater radiation hazard. The vitrified waste has a smaller volume than packaged spent fuel, but it still requires disposal in a deep geological repository, whose costs do not increase in proportion to the volume of the inventory. The parts of technological waste that contain long-lived radionuclides and must therefore go to geological disposal can present problems since the waste forms (cement, bitumen, compacted pieces) are less durable than vitrified waste or spent fuel.

The strongest argument in favor of reprocessing is that it saves resources, although the real benefits will be realized only when fast reactors are in use. A further positive aspect is that the highly active vitrified waste, in contrast to spent fuel, does not fall under International Atomic Energy Agency (IAEA) safeguards and presents no proliferation risk. However, the fact that current reprocessing technology involves separation of weapons-usable plutonium has led to concerns about the spread of the technology to many countries.

Disposal. Today, it is widely accepted in the technical community that the only presently feasible method to ensure very long term (many millennia) safety for high-level waste or spent nuclear fuel is

isolation in a stable, deep geological repository. Nevertheless, at present there are no disposal facilities (as opposed to storage facilities) in operation in which used fuel or the waste from reprocessing can be placed.

For at least 25 years after the original 1950s publication on the concept of geological disposal, the validity of this approach was not questioned. It was formally adopted as a final goal, through policy or legal decisions, in many countries, including the United States, Canada, Sweden, Finland, Belgium, Switzerland, France, Spain, South Korea, the United Kingdom, and Japan. However, virtually every geological waste disposal program in the world encountered difficulties in keeping to originally proposed schedules.

Despite the slow progress of geological repositories in many countries, advances have been made in some parts of the world. In the United States, the Waste Isolation Pilot Plant (WIPP) deep repository for transuranic wastes has been operating successfully for 10 years. In Finland, Sweden, and France, deep repository programs are very advanced, proving that sites can be selected with the consent of local populations; that all necessary technologies are mature enough for implementation; and that definitive dates for repository operation can be set. In most other countries of the world, the combined technical and societal approaches employed in Sweden and Finland are looked upon as role models. In 2008, when the U.S. Department of Energy submitted a license application for a geological repository at Yucca Mountain, the U.S. program was also perceived as being one of the most advanced. However, with the mid-2009 declaration by the new administration that Yucca Mountain is "not an option," the timescales to implementation may have been set back by decades.

The various stages in the fuel cycle have often been developed by focusing on how to optimize a specific process and not by taking into account influences on later stages. In the following sections, we present some back-end examples that illustrate this point and that highlight how more holistic thinking might drive future developments.

Storage. There are no major technical issues affecting the safety and security of spent fuel storage. Both wet and dry storage systems have been proven over decades. However, a specific disadvantage of pool storage is that a large facility must be constructed at the outset to allow for future accumulation of spent fuel. Another disadvantage is that maintenance can become expensive if final disposal lies far into the future. Pool storage has also been criticized as being particularly susceptible to terrorist attacks, although such vulnerability has also been refuted by technical bodies.

The security and terrorist concerns mentioned above have heightened interest in the potential advantages of building storage facilities underground. This approach has recently been considered in the work of the Committee on Radioactive Waste Management (CoRWM) in the United Kingdom, where such stores are referred to as "hardened" facilities. An alternative would be to have spent fuel storage facilities at repository depths (hundreds of meters) with the possibility of later converting these stores into final disposal facilities. Others have suggested, however, that this appears more like an effort to place waste in a geological facility without first having to demonstrate the suitability of the site for long-term isolation.

Globally, the spent fuel in storage will continue to grow over the coming decades. Even the first repositories in Sweden, Finland, or France will not begin operation for more than a decade, for technical and engineering reasons. Repositories in other countries will be established much later because of institutional delays, because sufficient inventories must first accumulate, or because funding is not yet available. Revived interest in reprocessing (but not at the present time or with the current technology) will lead some countries to extend surface storage in order to keep the option open. Therefore, global efforts are needed to ensure that safety and security are guaranteed at all storage facilities for spent fuel.

Reprocessing. Reprocessing was first developed on a large scale in military facilities in order to separate fissile materials for nuclear weapons. The environmental impacts, the security aspects, and the treatment of waste residues had lower priorities. The technologies commercially applied today are basically the same as they were when the technology was first developed, although much improvement has been made in reducing emissions and developing conditioning methods for non-high-level waste. Today, there is increased interest in recycling, but based on new developments that provide enhanced security by avoiding separated fissile materials.

The advantage of the current PUREX process is that it has been demonstrated to work in a highly reliable fashion. Key disadvantages are that it produces separated plutonium, which is a security risk, and that the plants required are large and expensive. Alternatives are being worked on. The UREX process, developed in the United States, is modified to separate only the uranium, which can be recycled, leaving the plutonium with the fission products and other actinides in "proliferation resistant" form. The COEX (co-extraction of actinides) process, developed in France, leaves a small amount of recovered uranium with the plutonium so that the plutonium is never separated. Approaches using pyrometallurgical and electrolytic processes to separate the fission products from the actinides have been developed and even operated at the pilot plant stage, but not under the current regulatory regimes, which may present significant challenges to their widespread use.

Geological Disposal. Geological disposal of high-level radioactive wastes and spent fuel is the key part of the nuclear fuel cycle that has not been demonstrated in practice. Technologies have been developed and extensively tested in a number of countries. These technologies are based on different conceptual designs for deep repositories; there are multiple feasible options for the choice of engineered barrier to enclose the used nuclear fuel and also for the geological medium in which the repository will be sited. In all of the programs, the safety of the deep geological system – as assessed by the range of scientific methodologies developed for this purpose – is invariably shown to be high. In the scientific community there is general acceptance of the feasibility of safe disposal, if the site and engineered system are well chosen. Unfortunately, political and societal acceptance remains a challenge in most countries.

The technical concepts developed to date in many countries are, however, generally recognized to be advanced enough for implementation. This does not imply that further technical optimization is unnecessary. In fact, even the most advanced programs are still amending engineering details in order to make the op-

erations in a deep repository safer and more efficient.

The largely technical information about the nuclear fuel cycle discussed so far makes clear that the necessary technologies for open or closed cycles have been developed to a level that allows their industrial application. Furthermore, it is clear that the nuclear fuel cycle is a global enterprise. This is in part because of the widespread and heterogeneous distribution of uranium ore bodies and partly because of the technological development history. The global distribution of fuel cycle technologies today is determined by various factors, including:

- The military origins and continued attractions of nuclear technology; this led to the present situation of seven countries with fuel cycle capabilities that include reprocessing;
- The distribution of natural resources; this has led to countries like Australia, with no nuclear power ambitions of its own as of yet, being directly involved in the fuel cycle as a producer of uranium ore;
- The desire for some degree of self-sufficiency in energy supply; this is a key driver in countries like Japan and a claimed driver in others like Brazil and Iran;
- The real or perceived opportunity to provide commercial services to other countries; this is a driver for enrichment and reprocessing facilities in Europe, the United States, and Russia;
- The recent hunger for clean base-load electrical energy; this is today leading to declarations of interest in expanding or introducing nuclear power in a long list of countries.

This global situation is in a state of flux. The economics and politics of energy supply are changing, and this will have repercussions on many aspects of supply and demand in nuclear fuel cycle services. More importantly, however, the issues of global safety and security are becoming of increasing concern. Intensive debate on these issues has taken place over the past years. Most emphasis has been placed on restricting the spread of enrichment and reprocessing technologies since these can directly produce weapons-usable materials. A more comprehensive approach, however, seeks to control the distribution of all nuclear materials that can be misused by states or by terrorist groups. In this section, we look at actual or potential geopolitical developments in the global fuel cycle that could lead to increased security risks and at measures that could mitigate these risks.

Nuclear programs expand and seek more independence. The spread of nuclear power reactors alone can obviously increase security risks at the back-end as well as the front-end of the fuel cycle. Since new nuclear programs have insufficient spent fuel inventories to justify repository projects and since there are currently few fuel providers that accept the return of spent fuel, expansion of reactor operations will also expand storage operations. If the stores are to operate for a very long period, then they will have to be maintained and safeguarded. These tasks become more necessary as the radiation from the spent fuel decays to levels that allow easier handling. Expansion of nuclear power plants thus implies that increased efforts to ensure safe and secure storage of spent fuel are needed. International initiatives have been suggested to meet this need.

Greater security concerns will arise if increased use of nuclear power by some

states leads them to conclude that they should implement indigenous facilities for sensitive fuel cycle activities: reprocessing or enrichment. Both of these activities are economically justified only if a sufficiently large nuclear fleet is operated (or if services are provided to foreign countries). Still, some countries may be tempted to push for national fuel cycle facilities even if they do not have this level of nuclear power production. Assurance of supply and national independence are obvious drivers. Since mastering either of the two sensitive technologies brings a nation close to the point where nuclear weapons can be produced, there is great international concern about the spread of these technologies.

Uranium producers move into other stages of the fuel cycle. At present, the high-tech stages of the nuclear fuel cycle are carried out by countries with nuclear weapons programs and/or with advanced civilian nuclear power programs. Some of the biggest uranium producers – Australia, Kazakhstan, and Namibia – fall into neither of these categories. It is not unreasonable for such countries to evaluate periodically the potential economic benefits of moving farther up the supply chain rather than simply exporting ores. Enrichment and fuel fabrication are obvious next steps. However, uranium producers could also conceivably offer back-end fuel cycle services. Reprocessing is unlikely to be introduced where it has not yet been done since very large scale technology is involved, and the economics are not favorable.

An undeniably attractive offer would, however, be a disposal service. In fact, in both Australia and Canada, the two largest uranium producers, the possibility of taking back as spent fuel the uranium that each country has supplied has been debated at different times. It has even been argued that such countries may have a "moral obligation" to accept spent fuel. However, the real driver for a uranium-producing country to accept returned spent fuel for disposal would be economic. Huge benefits could result for the host state, but despite this advantage, the political and public support for such an initiative has nowhere been evident.

The key role of the back-end in the nuclear fuel cycle

Disposal becomes multinational. For some countries, national repositories may be difficult or infeasible because of the lack of favorable geological formations, shortage of technical resources, or prohibitively high costs. Multinational or regional repositories are a potential solution for these countries, and in recent years there has been a rapid increase in interest in this possibility, especially in small countries. The prime drivers were originally the economic and political problems that might be lessened by being shared between countries facing the same challenges. The potential safety and safeguards benefits were also recognized at this early stage. Increasingly – in particular after the terrorist attacks in the United States in 2001 and in connection with nuclear proliferation concerns – attention has focused on the security advantages that could result. The IAEA has been careful to point out that risks must also be minimized at the "back-end of the back-end" of the nuclear fuel cycle – that is, not only in enrichment and reprocessing, but also in storage and disposal (of spent fuel in particular). In its publications in this area, the IAEA has described two potential routes to achieving international disposal: the "add-on approach" and the "partnering scenario."

Both of these potential approaches to multinational disposal have seen significant progress. The add-on option calls for a single country, or a network of coun-

tries with appropriate facilities working together, to provide extended fuel-cycle services to countries adhering to the Nuclear Non-Proliferation Treaty (NPT) and wishing to use nuclear power. This option could limit the spread of those sensitive technologies allowed under the Treaty – namely, enrichment, reprocessing, and accumulation of stocks of spent fuel. Crucial prerequisites would be securing supply of services to all cooperating users and close international monitoring by the IAEA.

Within this international fuel cycle scheme, the fuel leasing component is perhaps the most promising. The U.S. government has indicated its support for such a scheme in Russia through the Global Nuclear Power Infrastructure (GNPI) proposal or in the United States through the Global Nuclear Energy Partnership (GNEP) initiative. The proposals are primarily aimed at making the nuclear fuel cycle more secure, but they ultimately require the fuel suppliers to take back the spent fuel or for a third-party, trustworthy country to offer storage and disposal services. Unfortunately, neither initiative appears to be making much progress.

In both Russian and U.S. proposals, the service providers concentrate on offering enrichment, fuel supply, and reprocessing to client countries. Although both proposals mention the take back of spent fuel, this is a sensitive political issue in both countries. Even if in the future it becomes acceptable to return to U.S. or Russian manufacturers fuel that they had provided to client nations, this take back will solve only part of the problem. Spent fuel from other suppliers in the market must also be accepted; there are existing inventories of hazardous radioactive wastes that must also go to a deep disposal facility. A more comprehensive offer of disposal services is necessary. In fact, an offer of this type may be the only sufficiently attractive inducement for small countries to accept the restrictions on their nuclear activities that are currently being proposed by the large powers and the IAEA. The emphasis on ensuring security of supply of other services, such as reactor construction, fresh fuel, enrichment, and reprocessing, is misplaced. All of these services are supplied commercially at present, and a customer country currently has a choice of suppliers that may well be wider than would result from implementation of initiatives that create a two-tier system of nuclear supplier and user countries. The key inducement for small countries to give up some of the "inalienable" rights afforded them in Article IV of the NPT may well be the offer of a safe, secure, and affordable route for disposal based on a multinational repository in another country.

The second option for implementing multinational repositories – partnering by smaller countries – has been particularly supported by the European Union through its promotion of the potential benefits of shared facilities in a regional solution. For the partnering scenario, in which a group of smaller countries cooperates in moving toward shared disposal facilities, exploratory studies have been performed most recently by the Arius Association, which also co-managed the European Commission's SAPIERR (Strategic Action Plan for Implementation of European Regional Repositories) project on regional repositories. The project, funded by the European Commission, has carried out a range of studies that lays the groundwork for serious multinational negotiations on the establishment of one or more shared repositories in Europe. The studies have looked at legal and liability

issues, organizational forms, economic aspects, safety and security issues, and public involvement challenges. The proposal that resulted from SAPIERR was a staged, adaptive implementation strategy for a European Repository Development Organisation (ERDO).

At the pilot meeting of potential participants in an ERDO working group, 32 representatives from 14 European countries were present, all of whom had been nominated through their national governments, as well as observers from the IAEA, the European Commission, and American foundations. ERDO, if sufficient numbers of partner nations agree to the final proposals, will operate as a sister organization to those waste agencies from European countries such as France, Sweden, Finland, and Germany that have opted for a purely national repository program.

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If nuclear power is to expand in a safe, secure, and environmentally friendly manner, improvements in the back-end of the nuclear fuel cycle must occur in the coming years. This section outlines some recommendations, both technical and institutional, for improvement.

Centralized storage – maybe even underground. Concentrating national inventories of spent fuel at a few centralized locations rather than having distributed stores (some at decommissioned reactor sites) can obviously help reduce security risks, from malevolent acts in particular. Some countries already have underground storage facilities and others are considering this option. Given the increasing recognition that spent fuel is a valuable resource – but that reprocessing is currently very expensive – the probability that used fuel will be stored for many decades is rising. If this happens, then the arguments in favor of underground stores with enhanced safety and security will grow stronger.

Research on advanced reprocessing. The recent support for nuclear expansion in some countries has also led to proposals for expansion of reprocessing using the current technological approaches originally developed for extraction of plutonium for weapons. The GNEP initiative proposed implementing reprocessing facilities that were copies of current commercial plants. The scientific community, however, led by the National Academies in the United States, was quick to point out that this is unnecessary and uneconomic at the present time, and that it could lead to increased rather than decreased proliferation risks. Nevertheless, the ultimate need to recycle fissile materials was accepted, and the conclusion was drawn that research into advanced reprocessing technologies is the most appropriate strategy today. Future technologies may improve the economics, environmental impacts, and security aspects.

Optimization of engineering aspects of repositories. A variety of repository designs and operational concepts have been developed over the last 30 years. Most of these, however, have tended to be highly conservative, with the explicit aim of demonstrating that deep geological facilities can provide the necessary isolation of long-lived radioactive wastes over unprecedented timescales up to one million years. Relatively soon, the first facilities will be licensed and constructed, and therefore practical engineering issues will rise in importance. Mining and nuclear working methods must be coordinated in a manner that ensures operational safety and efficient operation. Quality assurance is a key challenge. In addition, the potential for cost savings must be addressed. The

work in the advanced Swedish and Finnish spent fuel disposal programs illustrates this well. In both of these cases, the original massive copper container has been redesigned to use less copper and more steel. Other disposal programs with differing safety concepts will likely face similar challenges.

Technical and financial assistance to new nuclear states. Leading nuclear nations must commit to work closely with young or new nuclear power nations to help them meet their energy needs and aspirations in a manner that preserves and improves security, nonproliferation objectives, transparency, and stability. The leading nuclear nations will have much better chances for success in assuring continued nuclear safety, security, nonproliferation, and environmental preservation if they work proactively with emerging nations to understand and help them improve their nuclear capabilities.

Providing technical and, in some cases, financial assistance to help emerging nations realize a secure and healthy energy future will be an excellent investment if it results in relationships that promote a high-quality nuclear safety and security culture. In the context of this essay, it is important to note that the assistance offered should extend to the back-end of the fuel cycle. An improved approach would be for providers of front-end services and of nuclear power plants to bundle support for repository design and construction activities with back-end services.

Multinational reprocessing facilities. Reprocessing plants that separate uranium, plutonium, and wastes from spent nuclear fuel can divert the plutonium to weapons use as well. As a result, there have been several attempts to pursue multinational solutions, though with little success to date.

With the spread of nuclear power, the advent of new technologies, and a greater focus on assuring decades-long supply of fresh fuel for nuclear plants, more countries may begin to consider the value of developing indigenous reprocessing facilities. It has also been argued that implementing this technology can ease the problems of waste disposal. However, the waste disposal advantages associated with reprocessing are not enough to justify the technology on their own. Thus, there are ample incentives to pursue the creation of multinational enrichment and reprocessing capabilities. Providing a framework that makes emerging nuclear nations meaningful participants in such initiatives holds great promise for better meeting both the energy and security needs of all involved.

Multinational interim storage facilities and repositories. As already emphasized, new nuclear nations will need assistance, particularly at the "back-end of the back-end" of the fuel cycle. Leading nuclear nations have the opportunity to craft "win/win" relationships by recognizing that many small nuclear programs, or countries starting out in nuclear energy, do not have the technical or financial resources to implement a national repository in a timely fashion. They will have to keep their spent fuel in interim storage facilities; this could result in numerous sites worldwide where hazardous materials could be stored for anywhere from decades to hundreds of years. Multinational cooperation in storage and disposal offers a better alternative.

One safer and more secure option would be for nuclear fuel suppliers to take back the spent fuel under fuel "leasing" arrangements, as described earlier. However, although there is fierce competition among nuclear suppliers to provide reactors, fuels, and reprocessing services, as yet few are willing to

pursue this leasing approach. Moreover, some would-be supplier nations, such as France, even have national laws prohibiting spent fuel take back unless the high-level wastes are returned to the user after reprocessing. The user country would therefore still require a geological disposal facility for these wastes. Cost savings, if any, in implementing a high-level waste repository rather than a spent fuel repository would be far outweighed by the prices charged for the reprocessing service.

The most promising option that remains open for small and new nuclear power programs is to collaborate with similarly positioned countries in efforts to implement shared, multinational repositories. The possibility that some country may decide to offer international repository services on a commercial basis cannot be excluded and could be a game changer.

The big challenge, of course, is achieving public and political acceptance in the repository host countries. Is it conceivable that a country and a local community within that country would willingly accept being a host for imported wastes? Recent national siting experience gives hope. Siting initiatives in several countries for either high- or low-level wastes have shown that success can be achieved through a modern strategy based on open communication, transparent documentation of potential benefits to host communities, steady accumulation of trust by the organization developing the repository, and recognition of the necessity of local acceptance. In a few countries (for example, Finland, Sweden, and South Korea), this has even led to competition between communities wishing to host a repository. At the multinational level, it is possible that the same strategy may also succeed, but as in the successful national programs, this may take several years.

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The ERDO initiative mentioned above could act as a role model for regional groupings elsewhere. A number of Arab states have recently made clear that they intend to introduce nuclear power, and have expressed a willingness to do so collaboratively. For example, in the Gulf Region, the United Arab Emirates is developing a complete roadmap, planning all of the activities involved in introducing nuclear power. Close linkages being formed today between nuclear programs in Brazil and Argentina might usefully expand into a Central and South American grouping. In Asia, countries like Taiwan and South Korea have already experienced problems trying to implement disposal programs, and various other Asian states, such as Malaysia, Indonesia, and Vietnam, have nuclear ambitions. An African regional grouping could also emerge, as various nations there have expressed interest in nuclear energy.

Joining forces in developing regional repositories could still have substantial advantages for small nuclear countries, even if the major nuclear powers at some stage reverse their policies and, for strategic or commercial reasons, finally do offer to accept foreign spent fuel or radioactive wastes. With a united front, and with the open alternative of a multinational regional repository, the partner countries would be much better placed in negotiations with potential large service providers over the economic and other conditions attached to any offer to take their spent fuel.

If the spread of nuclear energy production is to occur without increasing global risks of terrorism and nuclear proliferation, there must be close international scrutiny of all nuclear activities. This oversight will be easier if sensitive ma-

terials in the nuclear fuel cycle are handled, stored, and disposed of at fewer locations. Shared disposal facilities for the spent fuel and highly radioactive wastes at the back-end of the fuel cycle should be one key component in a secure global system. It would benefit all nuclear programs if initiatives for regional cooperation were started in relevant parts of the world by small or new nuclear countries, and if these initiatives received technical and moral support from the advanced national disposal programs.

Today, developed and emerging countries are striving to maintain or improve their standards of living by assuring a sufficient supply of energy; at the same time, they are striving to deal responsibly with global warming. Accordingly, prospects for a substantial growth and spread of nuclear power and associated facilities are increasing. For this growth to be successful, however, there are a number of concerns that need to be addressed, some technical and some economic. The potential for a systems approach to technical and economic optimization should certainly be examined, explicitly taking into consideration the holistic nature of the fuel cycle. The technical and economic challenges associated with expansion of nuclear power are, however, outweighed by the institutional concerns that need to be addressed.

Because the nuclear fuel cycle is global and because the consequences of misuse of nuclear materials are also global, all nations can be affected by the expansion of nuclear power. Multinational cooperation is essential for ensuring safety, security, and protection of the environment during this expansion. This cooperation must extend to the back-end of the nuclear fuel cycle.

Recent policy initiatives have focused on incentives to nations in the form of fresh fuel assurances in return for promises by recipient nations not to pursue indigenous enrichment or reprocessing. These offers have met with less than popular acceptance. To many in the emerging nuclear world, fresh fuel assurances by the developed nuclear nations look like the start of a nuclear fuel cartel. The assurances appear to perpetuate a division between nuclear haves and have nots, and ask emerging nuclear states to put themselves in a political situation that they believe might threaten their access to fuel in coming decades. Many would prefer a continuation of what they feel they already have: access to a healthy nuclear fuel marketplace.

Nonetheless, revisiting the nuclear bargain established by the NPT and related agreements is being pushed – for different reasons – by both the nuclear-weapons states and the emerging nuclear nations. These efforts present both a concern to many that the NPT may be fraying at the edges, but also a possible opportunity to build a new set of understandings and behavior that will better meet the energy, proliferation, and environmental needs of all concerned.

We should start with a set of clear goals. These goals must be responsive to the needs of the entire international community, not just those of the advanced nuclear provider states. The goals must also include measures at the back-end. The complete list of goals could include:

- Providing access to nuclear power at market prices for any country that desires it;
- Assuring nuclear fuel supplies through a fuel bank and healthy marketplace;
- Eliminating the rationale for enrichment and reprocessing for all but a select few, and ensuring that when

these activities do take place they are under international control/oversight;

- Securing all excess weapons-usable material by putting it in unattractive form or burning it where sensible, and bringing it under international control in appropriate countries; the ultimate goal is to draw down separated weapons-usable materials to as close to zero in as few places as practical;
- Disposing of spent nuclear fuel domestically or shipping it to appropriate countries for management and disposal under international oversight;
- Recognizing countries that agree to host multinational disposal facilities as providers of a necessary nuclear fuel cycle service;
- Entitling all countries that provide fuel cycle services at the front-end or back-end to reasonable commercial profits;
- Entitling countries that use foreign fuel cycle services at the front-end or back-end to security of supply; the unique nature and particular risks associated with nuclear power technologies imply that the above two points must be internationally guaranteed if the free market system fails to work effectively; and
- Ensuring that any move toward weapons development or weapons-usable material acquisition is surely, quickly, and clearly apparent.

Effectively integrating a successful approach to spent fuel and high-level radioactive waste management is a crucial component of pursuing such an agenda. The lack of a credible, sustained program to provide an ultimate solution to the disposal of these materials is a serious hindrance to a healthy nuclear power program. The growth and spread of nuclear power may well lead to more countries accumulating spent fuel. The subsequent buildup of this material in an increasing number of nations will provide a reservoir of plutonium that could later be accessed through reasonably quick and simple, and possibly covert, reprocessing techniques. Along with the spread of expertise and necessary technical knowledge, this buildup can bring countries closer to weapons creation and potentially set off regional instabilities as neighbors begin to hedge their nuclear bets as well.

The key role of the back-end in the nuclear fuel cycle

Creating an international initiative to explore the prospects for multinational spent fuel storage, with eventual multinational disposal of spent fuel or the high-level waste resulting from reprocessing, can begin a win/win process for solving the waste issue in a manner that addresses proliferation, energy, and waste management issues simultaneously. Companion efforts could pursue multinational enrichment facilities and, as needed, reprocessing facilities with opportunities for financial participation by emerging nuclear nations.

Established nuclear nations, particularly the nuclear-weapons states, should lead by example. As leaders, they can transform waste management and disposal from issues of "nuclear garbage" to integral elements of an internationally accepted system. This system not only would provide for the resurgence of nuclear power, but in doing so would simultaneously reduce proliferation, regional instability, and waste management concerns.

Siegfried S. Hecker

Lessons learned from the North Korean nuclear crises

In October 2006, some 50 years after North Korea began its nuclear journey, it detonated a nuclear device and declared itself a nuclear power. A second explosion, in May 2009, erased lingering doubts about its ability to build the bomb. It is instructive to learn how, but even more important to understand why, it built the bomb. Pyongyang has proclaimed its reason for going nuclear: "The DPRK made nuclear weapons and has strengthened its self-defensive war deterrent to maintain the sovereignty and the right to existence of the nation in the face of the increased aggressive threat by the U.S."[1] But is the alleged threat to Pyongyang's security the only reason it built the bomb? This essay briefly reviews what North Korea's nuclear capabilities are and shows how technical capabilities and political intent were inextricably intertwined in shaping the program. The essay then turns to Scott Sagan's theoretical framework of three models for the bomb[2] to show how Pyongyang's deep security fears, augmented by domestic and diplomatic drivers, have dominated its decision to build and keep the bomb. The essay concludes with lessons learned from North Korea for the nonproliferation regime.

The promise and peril of nuclear energy share a common technological foundation. Pursuit of a civilian fuel cycle – making fuel, building reactors to burn the fuel, and maintaining the back-end to deal with nuclear waste, including the option of extracting some of the valuable by-products from burning reactor fuel – enables nations to develop the capability to make bomb fuel, either highly enriched uranium (HEU) or plutonium. North Korea mastered the plutonium fuel cycle ostensibly for nuclear power and then used it to build the bomb.

This brief review of North Korea's acquisition of nuclear capabilities will only touch on the important political milestones that helped to shape it; a more complete discussion will be presented in the next section. Kim Il-sung, the country's founding father, laid the foundation for nuclear technology development in the early 1950s. The Soviet "Atoms for Peace" initiative, modeled after President Eisenhower's initiative of the same name, enabled several hundred North Korean students and researchers to be educated and trained in Soviet universities and nuclear research centers. The Soviets built a research re-

actor, the IRT-2000, and associated nuclear facilities at Yongbyon in the 1960s. North Korean specialists trained at these facilities and by the 1970s were prepared to launch a nuclear program without external assistance.

North Korea's decision to build gas-cooled, graphite-moderated reactors was a logical choice at the time for an indigenous North Korean energy program because gas-graphite reactors can operate with natural uranium fuel and, hence, do not require enrichment of uranium.[3] Although North Korea may have experimented with enrichment technologies, commercial enrichment capabilities were beyond its reach and difficult to acquire.[4] North Korea's ambitious program began with an experimental 5 megawatt-electric (MWe) reactor, which became operational in 1986. Construction of that reactor was followed by a scaled-up 50 MWe reactor and a 200 MWe power reactor, although neither was ever completed.

North Korea quickly mastered all aspects of the gas-graphite reactor fuel cycle. It built fuel fabrication facilities and a large-scale reprocessing facility, which enabled extraction of plutonium from spent fuel.[5] Unlike the Soviet-built research facilities, the new facilities were built and operated without being declared to or inspected by the International Atomic Energy Agency (IAEA). Pyongyang had no legal obligation to declare these facilities because it was not a member of the Nuclear Non-Proliferation Treaty (NPT). American reconnaissance satellites picked up signs of the reactor construction in the early 1980s and the reprocessing facility in the late 1980s. It was not until 1989, when South Korea leaked American satellite data of the reprocessing facility, that the international community first became aware of and concerned about North Korea's indigenous nuclear program. The concern stems from the fact that gas-graphite reactors are capable of producing weapons-grade plutonium while generating electrical power and heat. So, whereas Pyongyang's choice of gas-graphite reactors for its energy program was logical, it was also the best choice to develop a nuclear weapons option.

In parallel, North Korea asked the Soviets to build light water reactors (LWRs) to help meet North Korea's energy demands. North Korea joined the NPT in 1985 because the Soviets made consideration of LWRs contingent upon joining the Treaty. These reactors, though, never materialized because of the demise of the Soviet Union. Pyongyang kept inspectors out of its new facilities until 1992, by which time it had all of the pieces in place for the plutonium fuel cycle. This move coincided with several diplomatic initiatives and President George H.W. Bush's decision to withdraw all American nuclear weapons from South Korea. By this time, the 5 MWe experimental reactor produced electricity and heat for the local town, as well as approximately 6 kilograms (roughly one bomb's worth) of weapons-grade plutonium per year. The fuel fabrication and reprocessing facilities were operational, and the two bigger gas-graphite reactors were under construction.

In 1992, Pyongyang opened the window on its nuclear program for diplomatic reasons explained below, but closed it quickly when IAEA inspectors uncovered discrepancies between their own nuclear measurements at Yongbyon and Pyongyang's declaration. Pyongyang responded to IAEA accusations by announcing its intent to withdraw from the NPT. Pyongyang was apparently surprised by the sophis-

tication of the IAEA's nuclear forensics and by the strictures of the NPT. Negotiations started in June 1993 but stalemated. In 1994, when North Korea unloaded the reactor's fuel containing an estimated 20 to 30 kilograms of plutonium, Washington and Pyongyang came close to war before former President Jimmy Carter intervened and brokered a freeze.

Intense negotiations in Geneva led to the Agreed Framework,[6] which changed North Korea's nuclear technical trajectory dramatically. Pyongyang agreed to give up its indigenous gas-graphite reactor program for the promise of two LWRs to be supplied by the United States, South Korea, and Japan. The spent fuel rods unloaded from the 5 MWe reactor were repackaged by an American technical team and stored in the cooling pool for eventual removal from North Korea. Operation of the 5 MWe reactor, the fuel fabrication plant, and the reprocessing facility was halted and monitored by IAEA inspectors per special arrangement under the Agreed Framework. Construction of the two larger reactors was stopped.

Although Pyongyang halted its plutonium program during the Agreed Framework, it continued to expand its missile program, including by conducting a long-range rocket launch over Japan in 1998. It also explored uranium enrichment.[7] During its first formal encounter with Pyongyang in October 2002, the Bush administration, which was adamantly opposed to the Agreed Framework, accused Pyongyang of covertly pursuing the alternative HEU path to the bomb. This altercation effectively ended the Agreed Framework and changed Pyongyang's technical and political trajectory again.

In 2003, North Korea became the first nation to withdraw from the NPT. It expelled international inspectors and announced that it would strengthen its nuclear deterrent. By the end of 2003, which also marked the invasion of Iraq and the fall of Saddam Hussein, Pyongyang was eager to have Washington believe it had the bomb. It used my first trip to North Korea, an unofficial, Track II trip led by my Stanford University colleague John W. Lewis, to send that message back to Washington. In a carefully choreographed tour of the Yongbyon nuclear complex in January 2004, Pyongyang gave me remarkable access to nuclear facilities and nuclear scientists and allowed me to hold nearly a half-pound of plutonium bomb fuel (in a sealed glass jar), all to convince me it had a "deterrent."

Over the next five years, Pyongyang built and demonstrated its nuclear weapons capabilities while it was engaged off and on in the six-party talks, which it joined only because of Chinese pressure.[8] We do not know exactly when Pyongyang got the first bomb, but we know it made significant strides during the past five years. In the early 1990s, the CIA reported that North Korea may have had enough plutonium for one or two bombs. Albright and O'Neill[9] reported the uncertainty in that estimate, noting that it varied from 10 kilograms plutonium to perhaps less than 2 kilograms. They also reported that non-nuclear explosive experiments, which are prerequisites for a plutonium bomb, were conducted at Yongbyon in the 1980s, leaving little doubt that Pyongyang was pursuing the bomb.

Since its restart in 2003, the 5 MWe reactor has operated for approximately three years, but is currently not operational. The reprocessing facility is operational, but extensive corrosion of fuel fabrication equipment that occurred during the Agreed Framework left that

facility only partially operational.[10] North Korea has conducted three reprocessing campaigns since 2003. The reprocessed plutonium, combined with the roughly 2 to 10 kilograms North Korea may have produced before 1994, yields an estimated plutonium production of 40 to 60 kilograms, of which 24 to 42 kilograms are available for weapons today.[11]

North Korea also conducted two nuclear tests of plutonium devices, the first in October 2006 and the second in May 2009. The first was only partially successful; its explosion yield was estimated as slightly below 1 kiloton (compared to roughly 21 kilotons for the bomb at Nagasaki). The second was more successful, with an estimated yield of 2 to 4 kilotons. We know nothing about North Korea's nuclear design capabilities. I believe the test results indicate that North Korea can build a Nagasaki-like simple plutonium bomb with a yield of 20 or so kilotons, and most likely possesses a nuclear arsenal of four to eight such primitive weapons today. Based on the experience of other nuclear countries, North Korea appears a long way from developing both a missile and a warhead to launch a nuclear weapon to great distances. Fielding a nuclear weapon on its shorter-range No-Dong missiles would take less time, but it may require another nuclear test.

Following the initial 2002 altercation with the Bush administration over North Korea's alleged uranium enrichment program, Pyongyang denied ever having pursued such a program in spite of overwhelming evidence to the contrary. As part of its response to UN sanctions following the April 2009 missile launch, Pyongyang announced that it would now pursue enriching uranium for a domestic LWR program. On September 3, it informed the UN Security Council that it was in the final stages of enriching uranium, something that it could only have accomplished if it already had an active program long before April 2009. It appears that Pyongyang used the current crisis as an opportunity to admit to having a uranium program; however, that admission changes the North Korean threat very little. I still believe that Pyongyang has experimented with uranium enrichment for decades, but never developed it on an industrial scale.[12]

Pyongyang has pursued an extensive missile program for decades. It built its initial capability, obtained from the Soviets, into a formidable short-range missile force and developed an ambitious export business for re-engineered Soviet missiles. Its principal customers have been Pakistan, Iran, Syria, Libya, Egypt, and Burma. Pyongyang's long-range missile development has been slow and not a great technical success. After the 1998 launch, it delayed its second launch until July 2006, primarily because of the missile moratorium it declared in 1999. However, the second launch failed instantly when the rocket apparently hit the gantry. Its third test, in April 2009, successfully lifted the first two stages over the Pacific, but the third stage failed.

Many observers now look at the last two decades as a dismal diplomatic failure because Pyongyang's nuclear program was not eliminated. Let's take a closer look at what Pyongyang actually achieved technically – or, perhaps more importantly, what it did not achieve. It failed to get commercial nuclear power. Although Pyongyang now has nuclear weapons, its weapons program is much smaller than it would have been if left unchecked. With the capabilities it already had or was soon to complete by

the early 1990s, Pyongyang today could have an arsenal of a hundred or more nuclear weapons. Instead, it has enough plutonium for four to eight weapons and currently is not producing more. It has the capacity to put the 5 MWe reactor back into operation and produce one bomb's worth of plutonium annually for the foreseeable future, but it has not taken steps to do so, perhaps indicating that it believes its small nuclear arsenal provides a sufficient nuclear deterrent.

However, Pyongyang's export of missiles and nuclear technologies appears not to have been constrained. It has widely exported short-range missiles and manufacturing technologies. We have much less information about its nuclear exports. However, evidence is overwhelming that Pyongyang built a plutonium-producing reactor for Syria that was destroyed by an Israeli air raid in September 2007. It appears quite likely that it exported to Libya uranium hexafluoride, the precursor to HEU. There are also grounds to suspect nuclear cooperation with Pakistan and Burma.[13] Cooperation with Iran is the greatest concern because Iran is putting in place all of the pieces for a nuclear weapons option, and its nuclear capabilities complement those of North Korea.[14] The nature of the nuclear exports also suggests that North Korea may have undeclared uranium facilities.

No one outside Kim Jong-il's inner circle understands the decision-making process and motivations of North Korea's regime. I will use Sagan's framework to analyze Pyongyang's nuclear decisions and try to answer why it built the bomb. Sagan postulates three models for the bomb: the security model, the domestic politics model, and the norms model. The security model calls for states to build nuclear weapons to increase their security against foreign threats, especially nuclear threats. States that face nuclear-armed or vastly superior conventionally armed adversaries will eventually attempt to develop their own nuclear arsenals unless credible alliance guarantees with a major nuclear power exist.

Security concerns have been the central driver of the North Korean ruling regime since the birth of the nation after World War II. Much of Pyongyang's nuclear decision-making can be understood by examining how Pyongyang saw its security environment evolve over the years. The devastating Korean War, resolved only by an armistice, and the U.S. threat to use nuclear weapons likely moved Kim Il-sung to pursue nuclear weapons early on. He likely strengthened his resolve to pursue his own bomb when China, shortly after its own first nuclear test in 1964, turned down his request to share its atomic secrets.

The late 1960s were turbulent times in Pyongyang's relations with the West. South Korea's military was bolstered by U.S. troops and U.S. nuclear weapons on its soil. Pyongyang watched the Cuban missile crisis unfold in a manner that shed doubt on Soviet commitments to its allies. It witnessed the Sino-Soviet split and the Chinese Cultural Revolution. Each of these developments reinforced the notion that Pyongyang could only rely on itself for the North's security. Although Pyongyang fielded an immense conventional army and its deadly artillery along the Demilitarized Zone (DMZ) was poised to destroy Seoul, nuclear weapons would help to balance the U.S. nuclear presence in the South. Therefore, the political drivers existed to match Pyongang's sustained technological drive to develop or import the necessary reactor and reprocessing facilities to eventually build nuclear

weapons, a technological base that it completed by 1990.

By the early 1990s, Pyongyang's security environment deteriorated dramatically. As the Cold War drew to a close, Pyongyang lost financial assistance from the former Soviet bloc. Its archrival, South Korea, had pulled ahead economically as well as strengthened its military. China focused on its economic rise and reached out to South Korea, and Russia recognized the South as well. Pyongyang was devastated by these changes and began seriously to explore accommodation with the West, especially with the United States. Carlin and Lewis[15] believe that Kim Il-sung made the strategic decision to engage the United States and even accept U.S. military presence in the South as a hedge against potentially hostile Chinese or Russian influence.

Kim Il-sung took bold steps toward reconciliation with the South. He signed a North-South reconciliation agreement and North-South denuclearization agreement, which altered the security landscape and offered a potential resolution to the nuclear issue.[16] Following a difficult start with the Clinton administration, Pyongyang agreed to trade its gas-graphite reactors and associated fuel-cycle facilities for two LWRs and interim energy assistance in the form of heavy fuel oil. Carlin and Lewis point out that Pyongyang viewed the political provisions of the Agreed Framework, which called for both sides to move toward full normalization of political and economic relations, to be the heart of the pact.

However, reconciliation between Washington and Pyongyang proved difficult, as Washington saw the Agreed Framework primarily as a nonproliferation agreement. Struck by the Clinton administration as the best alternative to avoid war and put the North on a path to denuclearization, the Agreed Framework was opposed immediately by many in Congress who believed that it rewarded bad behavior. Congress failed to appropriate funds for key provisions of the pact, causing the United States to fall behind in its commitments almost from the beginning. The LWR project also fell behind schedule because the legal arrangements were much more complex than anticipated. The Agreed Framework, which began as a process of interaction and cooperation, quickly turned into accusations of non-compliance by both parties.

The 1990s were also particularly difficult times domestically for North Korea. In addition to geopolitical changes, North Korea lost Kim Il-sung and had to cope with a series of natural disasters that added to its economic devastation and decimated its industrial capacity. Its once mighty conventional military was decaying. Its hope for receiving the benefits of nuclear electricity to help bolster its sagging economy appeared a distant hope because of delays in implementation of the Agreed Framework. However, the diplomatic crisis resulting from its 1998 rocket launch over Japan was resolved by the Perry Process, which brought Pyongyang's second-ranking official, Vice-Marshal Jo Myong-rok, to the White House in October 2000.[17] The two sides issued a joint communiqué that pledged "neither would have hostile intent toward the other and confirmed the commitment of both governments to make every effort in the future to build a new relationship free from past enmity." This communiqué signaled to Pyongyang for the first time that the United States recognized the right of North Korea to exist. The follow-up meeting between Secretary of State Madeleine Albright and Kim Jong-il that was held in Pyongyang

a couple of weeks later appeared to put the nuclear crisis on a path to final resolution.

With the change in administrations in Washington, hope for a settlement was quickly dashed. Whereas Pyongyang was waiting for a U.S. response to the Perry Process, it ran into the Bush administration's adamant opposition to the terms of the Agreed Framework and to political accommodation. Pyongyang practiced restraint with the incoming Bush administration until North Korea was accused of a covert uranium enrichment program and saw the Agreed Framework come to an end. During the confrontation over enrichment in October 2002, First Vice Minister of Foreign Affairs Kang Sok-ju told his American counterpart, "We are a part of the axis of evil. . . . If we disarm ourselves because of U.S. pressure, then we will become like Yugoslavia or Afghanistan's Taliban, to be beaten to death."[18] Pyongyang withdrew from the NPT and restarted its dormant Yongbyon facilities to produce fuel for a plutonium bomb.

Pyongyang's security fears were further heightened by the invasion of Iraq. Pyongyang now believed the bomb would assure its survival, so it no longer hid its nuclear weapons aspirations. At the six-party negotiations, Pyongyang again declared its willingness to denuclearize in return for political accommodation and economic and energy assistance. Although Pyongyang signed the Joint Denuclearization Statement on September 19, 2005, the talks were mired in distrust and accusations. They led to alternate cycles of dialogue and confrontation.

Pyongyang viewed U.S. financial sanctions imposed at the same time as a breach of the denuclearization pact. It withdrew from the talks and launched a second long-range rocket in July 2006 and conducted its first nuclear test in October 2006. The test drew UN Security Council sanctions, but Pyongyang appeared to offset the negative effects of sanctions with increased diplomatic leverage. Later that year, the Bush administration radically changed its negotiating strategy with Pyongyang for the remainder of its term. It conducted bilateral negotiations under the umbrella of the six-party talks, something that Pyongyang had desired but that the Bush administration had refused to do for six years. Pyongyang viewed this change as a direct result of its new nuclear status, whereas domestic U.S. politics and the results of the 2006 congressional elections may have played a greater role.

During the remainder of the Bush administration, Pyongyang agreed again to halt its nuclear program, but not to eliminate it. During my visit three weeks after the nuclear test in 2006, North Korean officials made it clear that their negotiation strategy had changed. They considered North Korea to be a nuclear power and wanted to talk arms control with Washington, not denuclearization focused on the North.[19]

In early 2009, Pyongyang decided not to wait for engagement by the Obama administration, but instead took aggressive steps to enhance its missile program. These steps prompted more UN sanctions, which Pyongyang used as an excuse to walk away from all its international nuclear obligations and to restart its nuclear program, including testing a second nuclear device in May. Although security concerns continue to dominate its decision-making, Pyongyang's actions were most likely driven by domestic and diplomatic factors rather than an increased sense of insecurity.

Sagan's domestic politics model posits that nuclear weapons may serve the

bureaucratic or political interests of individual actors, such as the military, the nuclear establishment, politicians, or the public. Such actors or coalitions of actors may influence the state's decision-making. Sagan cites the Indian nuclear program as a particularly convincing case of the importance of domestic politics and the influence of domestic advocacy groups. He further demonstrates that domestic political factors played strong roles in nuclear decision-making in South Africa, Ukraine, Argentina, and Brazil.

Domestic politics are clearly different in North Korea. The Kim dynasty, father and son, has ruled the country with an iron fist and based its legitimacy, in large part, on a cult of personality of its leaders. To stay in power, the regime tightly controls all information, limits contact of its people with the outside world, and warns its people that external forces constantly threaten the very existence of their nation. External threats are used to justify keeping the country on a constant war-footing that requires continued sacrifices by and harsh treatment of its people. Natalia Bazhanova[20] points out that in communist countries the pursuit of nuclear weapons to meet external threats helps to increase tensions at home and distract people's attention from their daily grievances and the failures of the regime. The need for nuclear weapons drives home the severity of the external threat.

The need for nuclear weapons was not directly invoked with the public until 2003, when Pyongyang openly declared its pursuit of nuclear weapons. Propaganda was greatest after the long-range missile and nuclear tests in 2006 and 2009. Although Pyongyang's leaders have not had to contend with political opposition or public uprisings, the nuclear card, along with the missile program, has helped to emphasize the power and prestige of the regime. There was much speculation that a succession crisis was driving Pyongyang's decision-making in 2008, after Kim Jong-il was reported to have suffered a stroke and appeared frail. Kim Jong-il reemerged and appeared to have rearranged the domestic power structure and solidified his control. Still, any future succession crisis in the DPRK may make cooperation with the United States less likely, as potential leaders would want to avoid being branded as "weak" or as "appeasing" Washington in negotiations about the nuclear program.

Sagan's norms model views nuclear decisions as also serving important symbolic functions externally – both shaping and reflecting a state's identity. Norms and shared beliefs about what is legitimate and appropriate in international relations can drive nuclear decision-making. Symbolism becomes important. Nuclear weapons become part of what defines a legitimate, modern state. Sagan contends that the French decision to build nuclear weapons was more the result of French leaders' perceptions of the bomb's symbolic significance than its security calculus. Sagan also shows how international norms, such as the NPT, helped to restrain nations' nuclear ambitions and, in cases such as Ukraine, to relinquish a nuclear arsenal inherited from the Soviet Union.

Pyongyang does not appear to have allowed international norms to influence its nuclear decision-making. The record shows that its own needs always trumped international norms and obligations. Pyongyang signed the NPT because of the promise of Soviet LWRs, but did not sign the required safeguards agreement with the IAEA for years because it wanted to keep its nuclear construction hidden from the world.

Pyongyang withdrew from the NPT in 2003 and defied international norms and UN sanctions with its two nuclear tests and long-range missile launches. Pyongyang decided to hedge its bets during the Agreed Framework, violating the agreement and its NPT commitments by acquiring export-controlled materials and equipment from abroad in order to explore the uranium enrichment route to the bomb.

However, international symbolism and prestige derived from nuclear technologies and weapons played an important role. North Korea views itself as a small and weak nation in spite of its domestic propaganda to the contrary. Once Pyongyang acquired and demonstrated the bomb, it used the power and prestige derived from the bomb as a diplomatic lever to strengthen its negotiating position. Its decision to confront the Obama administration with a missile launch and a nuclear test was more likely an attempt to gain diplomatic leverage and possibly to support domestic changes, rather than an effort toward deterring an increased security threat.

Pyongyang may also simply have decided to take advantage of the transition to accomplish two objectives while the Obama administration was still formulating its Northeast Asia security policies and assembling its executive team. North Korea's long-range missile program needed additional flight tests, and Pyongyang needed to demonstrate to itself and the world that its nuclear weapons could do better than the 2006 test. The missile and nuclear tests must have been on the shelf ready to go for some time, looking for a convenient window.

What can we learn from how and why North Korea built the bomb? North Korea is unlikely to give up its nuclear arsenal anytime soon because it has become crucial to how the regime assures its security. Nuclear weapons also play a supportive role domestically and provide diplomatic leverage. Pyongyang views its security concerns as existential. They are deeply rooted in history and, hence, are unlikely to be resolved by alliances with its neighbors, each of which North Korea believes to have ulterior motives. Pyongyang turned to the United States, but it found Washington unreliable and inconsistent. In spite of having received numerous security guarantees that promised to respect its sovereignty along with assurances not to invade the country, Pyongyang still feels threatened today. It will require much more than another security guarantee to make Pyongyang feel secure.

Even if North Korea's security fears are assuaged, domestic factors favor keeping the bomb. The external threat is used to justify the need for the bomb and the sacrifices North Korea's people are asked to make. That threat also helps keep its people submissive and isolated from the international community. It also helps the regime continue to control all information and to blind its people to progress in the rest of the world, especially south of the DMZ. Paradoxically, compared to a more democratic country, an autocracy like North Korea may find it easier to give up its weapons if doing so is seen to help the regime survive, because it does not have to deal with domestic opposition.

Military might is the only source of Pyongyang's diplomatic power today. Nuclear weapons have become central to the projection of its military might, in spite of the fact that its nuclear arsenal has little war-fighting utility. Pyongyang views nuclear weapons as diplomatic equalizers with its much more prosperous and powerful, but non-nuclear rivals, South Korea and Japan. Without

nuclear weapons, North Korea would get scant attention from the international community.

Many believe that the bomb is only a bargaining chip and that North Korea is willing to sell it for the right price. However, for reasons stated above, there is no price high enough for Pyongyang to sell. It is also not about to give up its nuclear weapons first as a condition of normalization. Pyongyang may agree to denuclearize in principle, but it will drag out implementation as it did during the six-party process.

It is also unlikely that North Korea can be forced to give up the bomb. Realistically, military options are off the table unless North Korea initiates a conflict. Additionally, sanctions are ineffective without China's support, but China will not support sanctions that bring Pyongyang to its knees. Beijing fears U.S. intervention in North Korea more than it does nuclear weapons in its neighbor's hands. It wants peace and stability on the Korean peninsula.

As undesirable as it may sound, the best hope is a long-term strategy to contain the nuclear threat while tackling the North Korean problem comprehensively, but in discrete steps.[21] Both Beijing and Seoul favor taking the long view. Time is not on Pyongyang's side. The greatest threat to the regime is not from the outside, but from within. It can't hold back its people forever from the tide of change surrounding its borders. In the meantime, it is important to avoid a clash between Pyongyang and Seoul or Tokyo. And it is essential to stop Pyongyang from doing additional damage around the world through nuclear cooperation and exports. Beijing is likely willing to restrain North Korea from expanding its nuclear program and, most importantly, to stop it from exporting its nuclear materials or technologies. That is how our joint efforts should be directed to reduce this dangerous threat.

The lessons of North Korea will not be lost on other potential proliferators, particularly Iran. Pyongyang broke new ground in defying international norms and took advantage of the international community's inability to respond effectively. Restricting supply of nuclear technologies through international treaties, norms, and arrangements slows down, but does not stop determined proliferators. We must understand the demand side of nuclear proliferation. Motivation may change over time; it becomes more difficult to reverse proliferation the longer a nuclear program has been pursued and the more successful it has become. In North Korea's case, the security motivation was augmented by domestic and diplomatic considerations and also by time and increased programmatic success. Many have called Pyongyang's actions unpredictable and bizarre, but I find that they are most likely based on a deliberate calculus of its needs, its negotiating strategy, and the necessarily inexact science of negotiations and implementation.

North Korea demonstrated how a sustained technical effort can develop the nuclear weapons option under civilian nuclear energy cover and, by exercising its NPT Article X rights to withdraw from the Treaty, how that option can be exercised quickly once proper political conditions emerge. The choice of fuel cycle for the civilian cover is important. Pyongyang selected the gas-graphite reactor technology, which was the best dual-use option. A lack of transparency and cooperation with the IAEA should serve as a red flag of a state's nuclear weapons aspiration. Pyongyang also confirmed that producing the fissile material – plutonium in this case – is the

critical step. It was able to build the bomb rapidly once it had plutonium because it had tested the non-fissile components of the weapon beforehand. North Korea taught us that we should not underestimate the indigenous capabilities of nations willing to commit resources to build the bomb. Both Russia and China underestimated this capability and, consequently, misjudged the severity of the threat. In Washington, the threat was often exaggerated for political purposes. Hence, it is important to get accurate, publically available technical assessments of nuclear capabilities.

Pyongyang showed that a nuclear arsenal does not have to be large or sophisticated to be politically effective. Nuclear tests strengthened the country's hands and tied the hands of the international community. Thus, it is crucial to stop aspiring programs short of demonstrating their capabilities. All nuclear threats are not equal; prioritization is critical. The Bush administration killed the Agreed Framework for domestic political reasons and because it suspected Pyongyang of cheating by covertly pursuing uranium enrichment. Doing so traded a potential threat that would have taken years to turn into bombs for one that took months, dramatically changing the diplomatic landscape in Pyongyang's favor. On the other hand, the Bush administration did not deal effectively with North Korea's egregious, secret construction of a plutonium production reactor in Syria, which constituted a serious proliferation threat. Moreover, Pyongyang may also be engaged in similar, and perhaps even more dangerous, liaisons with the likes of Iran and Burma.

The United States plays an indispensable role in proliferation prevention, but it can't go it alone. It cannot afford to sit at the sidelines as it has done with Iran. We found that Pyongyang was willing to slow its drive for nuclear weapons only when it believed the fundamental relationship with the United States was improving, but not when the regime was threatened. Pyongyang was willing to tolerate the six-party negotiations, but progress was made only when Washington agreed to bilateral dialogue. Washington holds the key to incentives, but by itself cannot impose sufficient disincentives to eventually convince North Korea to give up its weapons. It must have support from Beijing and Seoul, both of which have very different strategic objectives.

The more divided we are at home, the more we yield advantage to the adversary. Political divisions in Washington in recent years resulted in our inability to negotiate the nuclear crisis effectively. American diplomats lament that it has been more difficult to negotiate in Washington than at the six-party table. Not only have we not been able to negotiate effectively, but also we have allowed Pyongyang to cross with impunity every red line we have drawn. The U.S. negotiating position has also been hampered by our inability to sustain consistent policies through transitions in administrations. Pyongyang has taken advantage of our political divisions to play a weak hand with success. Unless we learn from the lessons of North Korea, others may be able to do the same.[22]

ENDNOTES

[1] See the article by So Ki-sok, senior researcher from the DPRK (Democratic People's Republic of Korea; or, North Korea) Institute for Disarmament and Peace, in "Three Perspectives on Korean Developments," presented at a July 2009 meeting of the Council for Security Cooperation in the Asia-Pacific (CSCAP) Study Group on Countering the Proliferation of Weapons of Mass Destruction, http://csis.org/publication/pacnet-55-three-perspectives-korean-developments.

[2] Scott D. Sagan, "Why Do States Build Nuclear Weapons? Three Models in Search of a Bomb," *International Security* 21 (3) (Winter 1996/1997): 54–86; also updated in Scott D. Sagan, "Rethinking the Causes of Nuclear Proliferation: Three Models in Search of a Bomb," in *The Coming Crisis: Nuclear Proliferation, U.S. Interests, and World Order*, ed. Victor A. Utgoff (Cambridge, Mass.: MIT Press, 2000), 17–50.

[3] The gas-graphite reactors were patterned after the British Calder Hall Magnox reactor, whose technical specifications were readily available because they were widely disseminated in the United Kingdom.

[4] The alternative path for natural uranium-fueled reactors is a heavy water reactor, such as the Canadian CANDU reactor. This was India's choice for its first reactor, which was constructed by Canada with U.S.-supplied heavy water. However, after India used the plutonium produced by that reactor for its first nuclear test in 1974, it would have been difficult for North Korea to get external assistance. North Korea required external assistance because it did not have the capacity to produce heavy water.

[5] The reprocessing facility resembles an extension of the design of the Eurochem reprocessing plant in Belgium.

[6] The Agreed Framework signed between the United States and North Korea on October 21, 1994, in Geneva agreed to have North Korea freeze its existing nuclear program. In addition to U.S. supply of LWRs and delivery of heavy fuel oil, the two sides agreed to move toward full normalization of political and economic relations, and work together for peace and security on a nuclear-free Korean peninsula. See Joel S. Wit, Daniel B. Poneman, and Robert L. Gallucci, *Going Critical: The First North Korean Nuclear Crisis* (Washington, D.C.: Brookings Institution Press, 2004) for informative discussions of the Agreed Framework and North Korean crisis in the 1990s.

[7] In the late 1990s, Pyongyang is reported to have acquired centrifuge technology from Pakistan's A.Q. Khan, as reported by Pervez Musharraf in his book *In the Line of Fire: A Memoir* (New York: Free Press, 2006). Additional evidence, including the purchase of aluminum tubes suitable for centrifuge rotors from Russia and attempted purchase from Germany, is discussed in Hui Zhang, "Assessing North Korea's Uranium Enrichment Capabilities," *Bulletin of the Atomic Scientists* (June 18, 2009), http://www.thebulletin.org/web-edition/features/assessing-north-koreas-uranium-enrichment-capabilities.

[8] The six-party talks, which were initiated in 2003, involved the United States, North Korea, and its four neighbors: South Korea, China, Japan, and Russia.

[9] David Albright and Kevin O'Neill, eds., *Solving the North Korean Nuclear Puzzle* (Washington, D.C.: Institute of Science and International Security, 2002).

[10] For a detailed assessment of the state of the Yongbyon nuclear complex, see Siegfried S. Hecker, "Denuclearizing North Korea," *Bulletin of the Atomic Scientists* 64 (2) (2008): 44–49, 61–62.

[11] All of the plutonium estimates have high uncertainties. If we estimate a 10 percent loss during reprocessing (which includes waste and material held up in plant equipment), that reduces the amount to 36 to 54 kilograms before testing, leaving an estimated 24 to 42 kilograms after testing, assuming that North Korea expended 6 kilograms per test (roughly the amount in the Nagasaki plutonium bomb). In 2008, North Korea declared that it had 26 kilograms reprocessed and weaponized. (By that time, it had conducted one nuclear test

and it still had roughly 8 kilograms in the fuel rods that were reprocessed in 2009.) Although that number is low, it is possibly correct.

12 This point has been made in Siegfried S. Hecker, "The Risks of North Korea's Nuclear Restart," *Bulletin of the Atomic Scientists* (May 12, 2009).

13 The evidence for North Korean assistance to Syria is strong; see David Albright and Paul Brannan, "The Al Kibar Reactor: Extraordinary Camouflage, Troubling Implications," Institute for Science and International Security (ISIS) Report, May 12, 2008, http://isis-online.org/publications/syria/index.html. Evidence of cooperation with Libya is less conclusive, yet likely; see David E. Sanger and William J. Broad, "Tests Said to Tie Deal on Uranium to North Korea," *The New York Times*, February 2, 2005. Evidence of nuclear cooperation with Burma is weak, but possible; see Julian Borger, "Burma suspected of forming nuclear link with North Korea," Guardian.co.uk, July 21, 2009, http://www.guardian.co.uk/world/2009/jul/21/burma-north-korea-nuclear-clinton.

14 Siegfried S. Hecker and William Liou, "Dangerous Dealings: North Korea's Nuclear Capabilities and the Threat of Export to Iran," *Arms Control Today* 37 (2) (2007), http://www.armscontrol.org/act/2007_03/heckerliou; and Siegfried S. Hecker, "From Pyongyang to Tehran, with nukes," op-ed, *Foreign Policy* (May 26, 2009).

15 Robert Carlin and John Lewis, *Negotiating with North Korea: 1992 – 2007* (Center for International Security and Cooperation, Freeman Spogli Institute for International Studies, Stanford University, January 2008), http://iis-db.stanford.edu/pubs/22128/Negotiating_with_North_Korea_1992-2007.pdf.

16 The North-South Denuclearization Agreement signed on December 31, 1991, vowed that neither would test, manufacture, produce, receive, possess, store, deploy, or use nuclear weapons. The Agreement on Reconciliation, Nonaggression, and Exchanges and Cooperation between South and North Korea (also known as the Basic Agreement), signed on February 19, 1992, reaffirmed a 1972 Joint Communiqué that the North and South are determined to end the state of political and military confrontation and achieve national reconciliation; to avoid armed aggression and hostilities; and to ensure the lessening of tension and the establishment of peace and the desire to realize multifaceted exchanges and cooperation to promote interests and prosperity common to the Korean people. At the time, this agreement was the more significant of the two. The denuclearization agreement never received serious consideration for implementation.

17 Former Secretary of Defense William J. Perry led a North Korea policy review for President Clinton. The full report can be found at http://www.state.gov/www/regions/eap/991012_northkorea_rpt.html.

18 Charles L. Pritchard, *Failed Diplomacy: The Tragic Story of How North Korea Got the Bomb* (Washington, D.C.: Brookings Institution Press, 2007), 25.

19 For a detailed description of the political developments in North Korea during the past decade, see Mike Chinoy, *Meltdown: The Inside Story of the North Korean Nuclear Crisis* (New York: St. Martin's Press, 2008).

20 Natalia Bazhanova, "Economic Factors and the Stability of the North Korean Regime," in *The North Korean Nuclear Programs*, ed. Clay Moltz and Alexandre Mansourov (London: Routledge, 2000), 60.

21 In his 1995 analysis of the North Korean nuclear crisis, Michael Mazarr argued that complete denuclearization may be too high a standard for hard-core proliferators; progress will come instead in fits and starts. Michael J. Mazarr, *North Korea and the Bomb: A Case Study in Nonproliferation* (New York: St. Martin's Press, 1995).

22 The author is indebted for close readings and suggestions on an earlier draft made by Chaim Braun, Robert Carlin, Thomas Fingar, John Lewis, Michael May, Niko Milonopoulos, Scott Sagan, David Straub, Kevin Veal, and Philip Yun.

Jayantha Dhanapala

The management of NPT diplomacy

From its beginnings, the multilateral Treaty for the Non-Proliferation of Nuclear Weapons (NPT) has been flawed by deeply entrenched discriminatory features. Yet somehow it has emerged as the most widely subscribed-to disarmament agreement in the world, with 190 member states-parties.[1] The year 2010 marks the fortieth anniversary of the NPT's entry into force, and also serves as occasion for the Treaty's next five-year review by all member states. This review comes at a time when the strength of the NPT is being sorely tested by pressures arising from the original "bargain" between the nuclear-weapons states (NWS) and non-nuclear-weapons states (NNWS); by the litany of unfulfilled promises from past review conferences, especially the 1995 Review and Extension Conference and its discussion surrounding Article VI; and by the few instances of NNWS attempting to renege on their NPT obligations.

The NPT is a unique treaty in many ways. It seeks to combine the prohibitive aspect of a disarmament treaty (with regard to NNWS, in Articles I, II, and III) and the advisory approach of an arms control treaty (with regard to the NWS, in Articles IV and VI). It also contains a provision, in Article X, paragraph 2, for a conference to be convened 25 years after the Treaty's entry into force, to decide whether it should be extended indefinitely or "for an additional fixed period or periods." Article VIII, paragraph 3 of the Treaty also provides for review conferences at five-year intervals. If diplomacy is the application of tact, skill, and intelligence in the conduct of international relations among nation-states, then both of these Treaty provisions offer opportunities for the active exercise of diplomacy by states party to the Treaty.

Most treaties are designed to last for an indefinite duration and are frozen in time except for amendment procedures, which, at any rate, are normally difficult to implement. In this respect, the internal dynamics of NPT conferences assume special importance while the external context, including instructions from national governments, continues to have undisputed influence. Thus the 1995 NPT Review and Extension Conference and all other review conferences, held every five years since 1975, merit close analysis for the interplay of diplomatic efforts by NWS and NNWS and the impact these efforts have had on the future course of the NPT. The lead-up to

the 2010 Review Conference provides an appropriate moment to study this diplomacy, which includes examining how past conferences have been managed. NPT diplomacy is not merely the interaction of delegations at NPT conferences and in between; it is also the management of the conferences by the officers elected to the various positions by the states-parties, in view of the impact these officers have on the success or failure of the conferences. Often the most intractable issues do not necessarily cause conferences to implode and collapse without agreement if there is sufficient goodwill and creative diplomacy. By contrast, negative personal chemistry among key delegations and poor conference management are likely to exclude any hope of accommodation or compromise.[2]

The negotiating record of the NPT – as revealed especially in Mohamed Shaker's pioneering study[3] – indicates that the Treaty was largely a product of U.S. and, subsequently, USSR delegations that co-chaired the Eighteen Nation Disarmament Conference (ENDC), the negotiating body that preceded today's Conference on Disarmament. Prior to the ENDC, in 1959 the United Nations General Assembly (UNGA) adopted Resolution 1380 (XIV), which had been proposed by Ireland and called for NWS to refrain from providing weapons to NNWS.[4] Two years later, another Irish draft resolution on the "prevention of the wider dissemination of nuclear weapons" was also adopted by the Assembly. What makes the 1959 and 1961 resolutions distinctive is that both resolutions represent the views of the NNWS. Of the two resolutions, the second, Resolution 1665 (XVI), adopted unanimously in the UNGA on December 4, 1961, can be regarded as the genesis of the NPT.

The transition from the UNGA, where voting is equitable with each member state having one vote, to the ENDC, where, among the 18 states, the cochairs were in a clear position of authority and influence as Cold War superpowers, was significant. The more evenly balanced interests of NWS and NNWS in the Irish resolution mutated to a draft treaty that was heavily weighted toward the interests of NWS. At the same time, the cochairs were aware that the draft treaty had to attract the support of a wide range of NNWS.

The main opposition came from Germany and Italy, both of which felt that they were targeted. Their diplomacy helped limit the duration of the NPT to 25 years. Article VI – widely regarded as the disarmament pillar of the NPT – was the result of developing countries, NNWS like Mexico, whose redoubtable Ambassador Alphonse Garcia-Robles spearheaded the fight for the inclusion of this Article. By 1961, the Non-Aligned Movement (NAM), with member states from each continent, had its first summit in Belgrade. The 25 countries of NAM had pledged to pursue an independent foreign policy unattached to the two blocs and were beginning to assert influence in global politics. That Article VI was a watered-down version of what Mexico and others proposed and, eventually, was placed deliberately within the context of "general and complete disarmament" was perhaps the best possible outcome given the strength of the NWS in the ENDC. Garcia-Robles played a leading role in the conclusion of the 1968 Treaty of Tlatelolco, which made Latin America and the Caribbean the first inhabited nuclear-weapon-free zone. Later, he shared the 1982 Nobel

Peace Prize with Ambassador Alva Myrdal of Sweden, another outstanding disarmament diplomat.

In the formulation of Article X, paragraph 1 (the withdrawal clause of the NPT; now very much the center of discussion after the DPRK left the NPT), it is clear from the negotiating record that the United States introduced the clause, but that Egypt, Burma, Brazil, and Nigeria had a role in the final language adopted. The focus at the time was on states exercising their sovereign right to withdraw on the basis of other states-parties not complying with their obligations.

The NPT was signed on July 1, 1968, and entered into force in 1970. Its membership has expanded from 91 in 1975 to 190 in 2009. The three depositary states – the United States, Russia, and the United Kingdom – have strongly encouraged other states to join, contributing to this expansion. However, it is true that assertive U.S. diplomacy has succeeded in convincing many countries to join the NPT as NNWS. At certain stages, opponents of the NPT, such as India, have tried to counteract this diplomacy but without much success, especially in South Asia. A dramatic uptick in accessions was noticeable prior to the 1995 Review and Extension Conference. While sovereign countries of course make a decision to join the NPT according to their national interests, the entry of long-standing holdouts like Argentina, Brazil, and South Africa represents a diplomatic success for the depositary states.

Four review conferences were held in Geneva during the 1975 – 1990 period, with two of the conferences (1975 and 1985) seeing adoption of a Final Declaration by consensus and two (1980 and 1990) failing to do so. However, it is arguable whether the success or failure of review conferences can be judged by the adoption of a Final Declaration. First, although the rules of procedure for the conferences provide for voting, decisions are generally reached by consensus, out of an increasing concern not to be divisive in vital issues of security. This empowers individual delegations or small groups of delegations to obstruct consensus and prevent the adoption of a Final Declaration.

Second, adopting a Final Declaration is regarded by some as less important than a comprehensive discussion of how the NPT has been implemented in all of its aspects. That belief may appear to be a rationalization for failure in diplomacy. But the fact is that the adoption of a Final Declaration is the expression of collective political will. Failure to do so could be a symptom of deeper political malaise or a demonstration of dissatisfaction with specific aspects of the review process, such as when the Arab group of countries focuses on a demand for Israel to join the NPT as a NNWS. The adoption of a Final Declaration is also influenced by the prevailing global atmosphere. Thus, a Final Declaration at a review conference is undoubtedly a political barometer.

The 1975 Review Conference. As the first review conference, the 1975 Conference served as a precedent, with those NNWS that were part of NAM – functioning under the title "Group of 77" – ready to confront the three NWS in the NPT at the time: the United States, the USSR, and the United Kingdom. Article VI was the key area of dispute, and the Comprehensive Test Ban Treaty (CTBT) was a principal demand, in addition to security assurances for the NNWS. The adoption of a Final Declaration was less a reflection of diplomatic agreement

among the parties and more a tribute to the forceful personality of Conference President Inga Thorsson of Sweden, who is said to have pushed her own draft through after the Drafting Committee failed to reach consensus on the nuclear disarmament aspects. Mexico, as spokesman for the Group of 77, made an interpretative statement of the Final Declaration that was incorporated as a Conference document. Thus, participants arrived at an uneasy compromise.

The 1980 Review Conference. The 1980 Review Conference followed the remarkable success of the 1978 First Special Session of the UNGA devoted to disarmament (SSOD I), and expectations were high. The Carter administration had been weakened considerably by the overthrow of the Shah in Iran and the subsequent student takeover of the U.S. Embassy, with its staff held in a prolonged hostage crisis. U.S. diplomats were in no mood to accommodate NAM demands. Relations between the United States and the USSR were strained by the Soviet invasion of Afghanistan. NAM itself was divided by tensions between Iran and Iraq, which erupted into a nasty war after the Review Conference.

Sharp divisions arose over Article VI and the CTBT, security assurances, Article III, and nuclear-sharing insofar as it was contrary to Articles I and II. After the success of SSOD I, NAM was not prepared to settle for anything less than disarmament, and so a deadlock resulted, with no Final Declaration adopted.

The 1985 Review Conference. In preparation for the 1985 Review Conference, I chaired the third session of the Preparatory Committee (which decided on the current structure of the three Main Committees and apportioned the chairs of these committees to the Western, Eastern, and NAM groups) and went on to chair Main Committee I of the Conference, which was held during U.S. President Reagan's first term.

Israel had attacked and destroyed Iraq's safeguarded nuclear reactor by the time of the 1985 Conference. Despite this inclement atmosphere, NPT diplomacy reached new heights under the able presidency of Ambassador Mohamed Shaker of Egypt (himself an authority on the NPT). His innovative diplomacy included assembling a representative group of advisors who helped to steer the Conference to the successful adoption of a Final Declaration. Before that, however, numerous hurdles had to be cleared, as sharp and irreconcilable divisions arose over disarmament issues, especially the CTBT.

It was evident that instructions given to the U.S. delegation were very tight, and I conceived of a drafting exercise similar to the Shanghai Communiqué of February 28, 1972, from the end of President Nixon's historic visit to China. That communiqué had stated China's position and the U.S. position on many controversial issues separately and with no attempt to bridge the differences. Thus a draft that reflected an overwhelming majority of delegations expressing support for a CTBT with a few delegations holding a contrary view was drawn up and finally accepted, helping to break the stalemate that was preventing a consensus.

This formula of "agreeing to disagree" was unusual but helped in the adoption of a Final Declaration. The personal diplomacy of the leader of the U.S. delegation, Ambassador Lewis Dunn, who painstakingly built relationships with the main officers of the Review Conference throughout all sessions of the Preparatory Committee, was another ingredient in the success of the 1985

Conference. In the final hours of the Conference, the hard work on the more substantive issues was almost wrecked over a non-NPT-related dispute between Iran and Iraq. This dispute was also resolved by a drafting exercise, which satisfied both parties, and in the small hours of the morning, with the clock having been stopped, the Conference was successfully concluded.

The 1990 Review Conference. The 1990 Review Conference had to confront NAM's renewed demand for a CTBT, which could not be resolved through drafting tricks or innovative diplomacy. Although the Mexican delegation is accused of having "wrecked" the Conference, standing out resolutely against any compromise, it must also be stated that the president of the Conference and other key delegations lacked the flexibility to devise diplomatic solutions or procedural fixes.

On the other hand, the 1990 Conference is possibly an example of the limits of NPT diplomacy when the political context is so difficult that no diplomacy could overcome the differences among delegations. The lesson to be drawn is that politics and diplomacy must go together if multilateral conferences are to succeed. There has to be political will to adopt decisions in a conference; creative diplomacy alone will not be enough.

The management of NPT diplomacy

Preparations for the 1995 NPT Review and Extension Conference (NPTREC) and its month-long conduct presented a huge diplomatic challenge.[5] The NPT depositary states, led by the United States, were clear that an indefinite extension was their goal, and U.S. diplomats, particularly Ambassador Thomas Graham, Jr., worked with national governments to achieve this end. (Ambassador Graham's book *Disarmament Sketches* describes his efforts.) While Russia, the United Kingdom, and France supported the same objective, there was no evidence of the same organized diplomatic offensive from them. China maintained publicly that it wanted "a smooth extension" but, with one eye on NAM, declined to be more explicit or active. The political atmosphere around the 1995 NPTREC was made favorable by the Clinton administration's decision to begin negotiating a CTBT in the Conference on Disarmament, thus removing one of the most contentious issues in NPT conferences.

South Africa was a key target of U.S. diplomacy, following Nelson Mandela's assumption of leadership of the nation and its emergence as a non-racial democracy replacing the white minority regime of the past. More significantly, South Africa had joined the NPT as a non-nuclear-weapons state after destroying its nuclear devices under International Atomic Energy Agency (IAEA) supervision. A special link on key NPTREC issues is said to have been established between U.S. Vice President Al Gore (who addressed the opening of the NPTREC) and South African Vice President Thabo Mbeki, ensuring South Africa's support for an indefinite extension of the NPT. This was an undoubted diplomatic triumph, especially as South Africa had proposed another 25-year extension during the Preparatory Committee stage.

The United States attempted similar diplomacy with the Arab group of countries, Egypt in particular, but was less successful. The Egyptian Foreign Minister at the time, Amr Moussa, remained critical of Israel's rejection of the NPT and demanded a solution to this rejection, calling for the Middle East to become a weapons of mass destruction–free zone. Another critic of U.S. NPT

policy was the able Mexican diplomat Miguel Marin Bosch, who was marginalized under U.S. pressure. A series of articles in *The Washington Post* on the eve of the NPTREC outlined U.S. policy and its diplomatic efforts. In marked contrast to the well-organized U.S. diplomatic offensive, the NAM countries had no similar campaign. No alternative to indefinite extension was conceptualized clearly or pursued vigorously, although many delegations proposed extensions of varying length since an extension would have given NAM the leverage it wanted. Even the critics outside the NPT, like India, made no effort to see that their wishes for a deadlocked conference were realized by way of an organized NAM stance.

The officers for the 1995 NPTREC, principally the president, were identified at an early stage. Two names, including my own, were proposed for the presidency at the very first session of the Preparatory Committee, and I was confirmed as president at the second session. This jump start provided ample time for consultations to be conducted and for diplomatic strategies to be planned. (In contrast, the confirmation of the president-elect for the 2010 NPT Extension and Review Conference was confirmed at the third session of the Preparatory Committee in May 2009.) Because of the complexity and importance of the 1995 NPTREC in comparison to other five-year review conferences, four sessions of the Preparatory Committee were necessary, and yet there was no complete agreement on the rules of procedure.

The diplomatic wrangling surrounding the rules of procedure was concerned with the mode of voting: would voting be conducted by secret ballot or by open ballot, if the Conference came to voting? NAM countries overwhelmingly preferred the former while the Western group preferred the latter. The importance of this decision revolved around the wording of Article X, paragraph 2, which stipulated that the extension decision be taken "by a majority of the Parties to the Treaty." This deadlock remained unresolved throughout the NPTREC, and it was just as well that the final package of three decisions and the Resolution on the Middle East were adopted without a vote.

At the opening of the Conference it was clear to me as president, through interviews with delegations that had not openly announced their extension preferences, that the majority needed for an indefinite extension did exist. It was therefore left to me to craft a procedure that would legitimize this as well as reflect the overwhelming view that the extension should be conditioned on specific guarantees that nuclear disarmament would be achieved. To respond to that challenge, a small group styled the "President's Consultations," along the lines of Ambassador Shaker's group from 1985, was adopted. The group included all Conference officers, the chairs of the political groups, and key delegations selected by me. It was conceived as an "inner cabinet," or a laboratory, to discuss the all-important extension issue, which transcended the normal business of the Main Committees. The device was not entirely undemocratic or lacking in transparency because group leaders (and all delegations belonged to a group, except for China) were encouraged to report back to their groups regularly and seek their endorsement on the decisions being taken.

The fact that the results of these consultations were endorsed by the entire Conference proved that success came from effective multilateral diplomacy rather than from seeking to arrive at

decisions in the plenary through unwieldy debate. The composition of the group was undoubtedly arbitrary, and that was resented by some of the delegations that were excluded, particularly by their ambassadors, whose egos were bruised. In terms of conference diplomacy, however, it was the practical and effective thing to do. It was within this group that two decisions – "Strengthening the Review Process for the Treaty" and "Principles and Objectives for Nuclear Non-proliferation and Disarmament" – were drafted over a two-week period. With all delegations now asserting their right to participate fully in decision-making, it is doubtful that the same device could be adopted in the future.

As president, I handled the drafting of the key legal decision on extension and the weaving of it and the other two decisions into a package, which I announced to a large representative gathering. The dispute over the rules of procedure – whether voting should be secret or open – was unlikely to have been resolved given the strongly held positions. I would have had to break the deadlock with a vote, and my decision whether that was to be by open or secret vote would itself have been highly contentious. It was also my conviction, which I voiced repeatedly, that voting on a treaty as important as the NPT would expose the Treaty membership as a house divided, eroding the viability of the Treaty. As president of the Conference, my main task was to fulfill the terms of Article X, paragraph 2: that a decision on extending the Treaty had to be taken by a "majority of the parties to the treaty." What better way to accomplish this task than by agreeing that there was a consensus that such a majority existed? The formulation thus presented by me was irrefutable and was met with widespread agreement. In any event, the package was not unwrapped, but some tinkering of the wording in Decision I was agreed upon, including dropping the words "a consensus" for simply "deciding that, as a majority exists." This satisfied the purists among the NAM members who resisted being a part of the consensus. And yet, because they could not deny that a majority did exist for an indefinite extension, they agreed that the entire package would be adopted without a vote!

The contentious issue of the Middle East, which, according to the wishes of the Arab Group, had proceeded on a separate track, had not made any progress, and I was approached for a solution at a very late stage of the Conference. This resulted in special consultations on a Resolution on the Middle East, with key delegations present, and an agreement was finally reached. Failure to consult Iran proved almost disastrous when the Resolution came up for adoption but was resolved during a recess in the plenary on the final day.

While the extension aspect of the Conference appeared to have been conducted successfully, the review aspect in the key political areas handled by Main Committee I was a diplomatic failure. (Main Committees II and III, thanks to the efficiency of their chairmen, successfully concluded their work on technical aspects on the NPT.) My last-minute intervention to rescue the process in Main Committee I did not succeed. This was not, in the final analysis, a major setback since the main outcome – a decision on extension – had been achieved.

The two conferences of 2000 and 2005 offer a study in contrast: 2000 saw the adoption of a landmark Final Declaration, with its well-known "13 Steps" (see Figure 1); 2005 ended in disarray.

Figure 1
The 2000 NPT Review Conference and the 13 Practical Steps: A Summary

At the 2000 Nuclear Non-Proliferation Treaty (NPT) Review Conference, states-parties agreed to take 13 "practical steps" to meet their commitments under Article VI of the NPT.

1. The early entry into force of the Comprehensive Test Ban Treaty (CTBT).
2. A nuclear testing moratorium pending entry into force of the CTBT.
3. The immediate commencement of negotiations in the Conference on Disarmament on a non-discriminatory, multilateral, and effectively verifiable fissile material cutoff treaty. The negotiations should aim to be concluded within five years.
4. The establishment in the Conference on Disarmament of a subsidiary body to deal with nuclear disarmament.
5. The principle of irreversibility to apply to all nuclear disarmament and reduction measures.
6. An unequivocal undertaking by nuclear-weapons states to eliminate their nuclear arsenals.
7. The early entry into force and implementation of START II, the conclusion of START III, and the preservation and strengthening of the Anti-Ballistic Missile Treaty.
8. The completion and implementation of the Trilateral Initiative between the United States, the Russian Federation, and the International Atomic Energy Agency (IAEA).
9. Steps by all nuclear-weapons states toward disarmament including unilateral nuclear reductions; transparency on weapons capabilities and Article VI-related agreements; reductions in nonstrategic nuclear weapons; measures to reduce the operational status of nuclear weapons; a diminishing role for nuclear weapons in security policies; the engagement of nuclear-weapons states as soon as appropriate in a process leading to complete disarmament.
10. The placement of excess military fissile materials under IAEA or other international verification and the disposition of such material for peaceful purposes.
11. Reaffirmation of the objective of general and complete disarmament under effective international control.
12. Regular state reporting in the NPT review process on the implementation of Article VI obligations.
13. The development of verification capabilities necessary to ensure compliance with nuclear disarmament agreements.

Source: Taken from the compilation by Claire Applegarth in *Arms Control Today* (January/February 2005).

One conference saw active diplomacy working toward a positive conclusion while the other, under the Bush administration and with Ambassador John Bolton as Permanent Representative of the United States, was polarized from the beginning, with little or no bridge-building efforts.

The run-up to the 2000 Review Conference was helped by the conclusion of the CTBT and its signature by several countries, although the U.S. Senate rejected its ratification. The Indian and Pakistani nuclear tests of 1998 were undoubted setbacks; however, these two countries were bound neither by the NPT nor the CTBT. The Preparatory Committee sessions were also marred by persistent efforts of the NWS to conduct "business as usual," ignoring the

major changes achieved in 1995 in terms of strengthening the review process. In marked contrast, the 2000 Review Conference itself proved a success. Conference President Ambassador Baali of Algeria demonstrated that a background in disarmament diplomacy was not necessarily a prerequisite so long as you had multilateral diplomatic skills. Main Committee I Chairman Ambassador Camillo Reyes of Colombia and the chairman of the subsidiary body on Article VI issues, Ambassador Pearson of New Zealand, showed great diplomatic skills in guiding their discussions to a consensus. The conference almost ran aground on a dispute between Iraq and the United States, but even this was eventually resolved. Thus, the needs of good conference management were well served.

The 13 Steps and the "unequivocal undertaking" of the NWS to achieve the elimination of nuclear weapons were among the successes of the 2000 Conference, although subsequent events were to show how ephemeral this could be. The lead-up to the 2005 NPT Review Conference was inauspicious. The NWS began to retreat from the 13 Steps, the Bush administration's Nuclear Posture Review of 2002 envisaged the actual use of nuclear weapons, and the United States and its allies invaded Iraq in 2003. The DPRK and Iran continued to be regarded with concern. The Conference failed to adopt a Final Declaration and was described by one commentator as "the biggest failure in the history of this Treaty."[6] Disagreement among the parties arose along all of the fault lines, and only four-and-a-half days of the four-week-long conference were spent on substantive issues. The rest of the time was spent on procedural wrangling – surely a recipe for the failure of any conference. Whether this focus on procedure was the intent of those who wanted no substantive discussion or whether it was accidental is not clear.

The management of NPT diplomacy

Politically, the lines were drawn when the Bush administration rejected the 2000 Final Declaration and all references to it, leaving little room for diplomacy. The New Agenda Coalition (NAC) – Brazil, Egypt, Ireland, Mexico, New Zealand, South Africa, and Sweden – which had been so active in the 2000 Conference, was a pale shadow in 2005, perhaps because of changes in leadership or a basic lack of cohesion. A new group emerged – the "NATO 7" – comprising The Netherlands, Belgium, Italy, Spain, Norway, Lithuania, and Romania, but even their efforts could not rescue the Conference. The NAM countries were not united. Egypt seemed determined to end the Conference without sacrificing any of the gains achieved in 2000, even if it meant a failed Conference. The political climate clearly doomed the 2005 Conference to failure. Except for a few delegations, such as the NATO 7, few were interested in salvaging the Conference through diplomatic initiatives. Squabbling over procedure was no substitute for diplomacy, but there was little else to do given the huge disagreements.

A number of features of NPT diplomacy bear mentioning as the 2010 Review Conference approaches, especially with the third session of the Preparatory Committee having been concluded successfully on May 15, 2009, in New York (albeit without agreement on a set of recommendations). While delegation positions follow instructions from national governments, it is not surprising that some act at their own discretion within the limits of flexibility permitted by their governments. This flexibility allows for individuals to show initiative in finding solutions to problems. It is also

possible that the stances taken by individual delegations on the conference floor can be changed as a result of diplomatic demarches by powerful countries compelling delegations to change their positions. Given the confidentiality of diplomatic communications, we will not know what pressures are exerted on NPT parties or what linkages are made as a part of the ongoing diplomatic activity in conferences.

The functioning of various groups within NPT conferences is an important element of NPT diplomacy, although the groups can sometimes be a help and sometimes a hindrance. The groups are: the Western Group, which includes Japan, Australia, NATO, and the EU; the Eastern Group, which includes Russia and the former USSR states but which has no political role and functions today only to agree on common candidates for NPT positions; and NAM, which decides collectively on political issues but is subdivided into the Asian, African, and Latin American & Caribbean groups for purposes of agreeing on candidates for NPT conference positions. In addition, NAM has within it the Arab group, which meets to discuss and decide on Middle East issues. (NAM generally accepts the positions of the Arab group.) The five NWS meet among themselves during conferences and in between. After some of these meetings, joint statements are issued representing common positions.

No group exists uniting all NNWS, and it is left to temporary coalitions like the NAC to form transcontinental groupings to espouse common positions. Such groupings can be very effective; it has been an omission that more diplomatic energy has not gone into forging such alliances to serve as "bridge builders" among the Treaty parties and to act as a "fire brigade" to defuse controversies as well as seek negotiated solutions to problems as they arise.[7] Group meetings usually take place prior to the commencement of the day's conference proceedings, but can also be held at any moment to coordinate group positions.

The political strength of NAM derives from its numbers and its solidarity, providing protection for the smaller and weaker countries within it. The other groups do not always welcome NAM's strength. Countries within the Western Group do not always find themselves in agreement.

As noted earlier, the selection and appointment of officers for review conferences should be done in a careful and timely manner and not left to fortuitous circumstances. Not every chairman or president need have detailed knowledge of the NPT and its history, provided he or she has the necessary diplomatic skills to strive for a consensus that strengthens the Treaty.

The Secretariat of NPT Conferences is staffed by members of the UN's Office of Disarmament Affairs and the IAEA. While they are international civil servants who are mandated to help service the needs of conferences through their experience and objective vantage point, they could often provide advice to help the outcome of the conference. In this regard, the "institutional deficit" the NPT faces must be remedied. There is no permanent body that acts as an administrative entity for the NPT. The UN staff who do perform functions related to the NPT do so in addition to their other duties. Ireland and Canada have presented working papers on this subject, and nongovernmental organizations (NGOs) have also raised it. Adding infrastructure to the NPT would greatly aid the exercise of NPT diplomacy. To oppose that infrastructure because of the cost seems shortsighted.

NGOs representing civil society are another significant element of NPT diplomacy. While the quality of NGOs may vary, and while some perform more of a think tank or research role, others can be useful pressure groups. Increasingly, NGOs play a diplomatic role. Some have representatives within delegations. Others organize briefing seminars for delegations, providing extremely useful background for young diplomats who are attending their first NPT conference and who want to understand past proceedings and details of current issues. These seminars and the briefing books made available also afford the opportunity of beginning discussions in an informal setting, which could lead to consensus when the conference actually begins.

By its very structure and content, the NPT encourages the practice of diplomacy in its conferences. It is a living treaty that, despite its seemingly impossible amendment procedure, has adapted and changed through the Final Declarations of its review conferences and the NPTREC's package of decisions. It is the only multilateral treaty that commits NWS to nuclear disarmament. Despite problems within the NPT, its conferences are well attended and attract widespread media attention. The longevity of the NPT and its near universality are a tribute to the multilateral diplomacy that has supported it.

However, diplomacy must be informed by a political will to make the NPT work. Absent that political will, the NPT cannot be sustainable, especially with its division of the world into NWS and NNWS. In a May 14, 1995, *New York Times* article, Barbara Crossette quoted me as having said: "The President of [an NPT review] conference is not a magician who can produce a rabbit out of a hat. The rabbit must be in the hat and must want to come out. All we can do is to coax it occasionally." NPT diplomacy is, in the end, a coaxing process.

ENDNOTES

1 This number includes the Democratic People's Republic of Korea (DPRK), which announced its withdrawal from the NPT in 2003. See also United Nations Office for Disarmament Affairs, "Status of Multilateral Arms Regulation and Disarmament Agreements," http://disarmament.un.org/TreatyStatus.nsf (accessed May 27, 2009).

2 Jayantha Dhanapala, with R. Rydell, "Multilateral Diplomacy and the NPT – An Insider's Account" (Geneva, Switzerland: United Nations Publications, 2005), 16.

3 Mohamed I. Shaker, *The Nuclear Non-Proliferation Treaty: Origin and Implementation, 1959 – 1979* (London: Oceana Publications, 1980).

4 In the same year, UNGA resolution 1378 (XIV) put "general and complete disarmament" on the UN agenda, where it has remained ever since.

5 A detailed description is provided in my "Multilateral Diplomacy and the NPT – An Insider's Account," cited above.

6 Harald Müller, "The 2005 NPT Review Conference: Reasons and Consequences of Failure and Options for Repair," Weapons of Mass Destruction Commission, Paper No. 31, August 2005, http://www.wmdcommission.org/files/No31.pdf (accessed May 27, 2009).

7 See also Jayantha Dhanapala, "The NPT Review Process: Identifying New Ideas to Strengthen the Regime," *The Enhanced Review Process: Towards 2000*, United Nations Institute for Disarmament Research (UNIDIR) Newsletter, No. 37, 1998, 10.

William C. Potter

The NPT & the sources of nuclear restraint

The past decade has not been kind to the nuclear nonproliferation regime.[1] Indeed, since the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) was extended indefinitely in 1995, it has been subjected to a series of body blows, which have led many nonproliferation experts, policy-makers, and media pundits to prophesize an impending cascade or chain of nuclear weapons spread, as well as the possible demise of the NPT as we currently know it. Implicit in many of these forecasts are assumptions about proliferation dynamics that are poorly informed by empirical research on past nuclear renunciation decisions. This essay draws upon this literature to assess the role the NPT has played in promoting prior nuclear restraint. It also examines how evolving international developments may alter the future effectiveness of the NPT as a proliferation constraint.

A review of recent commentary about nuclear proliferation imparts little reason for optimism that the NPT will withstand a large and growing set of challenges that emanate both from outside and within the Treaty. A short list of external challenges includes:

- The rise of non-state actors as nuclear suppliers, middlemen, and end-users, and the tendency on the part of many states to assume that the threat of nuclear terrorism is someone else's problem;
- The inadequacy of fissile material protection, control, and accounting in many states, and corresponding deficiencies in nonproliferation export controls;
- A nuclear arms race in South Asia and the general disinclination by and/or inability of the international community to do anything to redress the situation;
- Defection from the NPT by North Korea;
- Iranian nuclear brinkmanship;
- Perceived rewards to states not party to the NPT and to nuclear weapons possessors;
- Continued reliance on nuclear weapons by all nuclear weapons possessors;
- Subordination of global nonproliferation objectives to other domestic and regional economic and political considerations by states party to the NPT;

- An uncritical embrace of nuclear power by most states without adequate attention to the full range of economic, safety, terrorism, and opportunity costs; and
- Complacency and ignorance about issues of disarmament and nonproliferation on the part of otherwise well-educated citizens and their elected officials.

Internal challenges stemming from the nature of the NPT itself tend to be less well known, and include such dangers as:

- Inadequate adherence to and implementation of NPT provisions by states party to the Treaty, compounded by the absence of an effective enforcement mechanism;
- Treaty inattentiveness to non-state actors;
- The conflict between the inalienable right to peaceful nuclear use and the prudent exercise of that right;
- Failure by most nuclear-weapons states (NWS) to address the demand of many non-nuclear-weapons states (NNWS) for negative security assurances;
- The near impossibility of amending the Treaty to correct flaws or to take account of new conditions;
- The weakness of the strengthened review process, including the difficulty of policy innovation due to reliance on decision-making by consensus;
- Lack of Treaty universality;
- Disavowal of and/or disregard for key elements of the 1995 NPT Review and Extension Conference package of three decisions and one resolution and the Final Document of the 2000 NPT Review Conference by both NWS and NNWS; and
- Reevaluation by a number of NPT states-parties of the value of the NPT for their security, raising the prospect of additional NPT defections.

These challenges to the nonproliferation regime are real and merit serious attention and corrective action. To enumerate them without also taking note of countervailing positive nonproliferation developments, however, is to convey a sense of doom that is misplaced.

First, it is important to recognize that the pace of proliferation has been relatively slow since the United States first tested a nuclear explosive in 1945. The number of nuclear weapons possessors today also is far less than anticipated by many prognoses made in the 1950s through the 1970s.[2] The 1957 U.S. National Intelligence Estimate, for example, identified a list of 10 leading nuclear weapons candidates, including Canada, Japan, and Sweden, the latter of which was predicted as "likely to produce its first weapons in about 1961," while Japan was estimated to "probably seek to develop weapons production programs with the next decade."[3]

It also is the case that proliferation is neither inevitable nor irreversible. Many countries with the technical capability to acquire nuclear weapons and that previously were regarded by intelligence analysts and scholars as prime candidates for proliferation chose to forgo that option, and four countries that either indigenously developed nuclear weapons (South Africa) or inherited them (Belarus, Kazakhstan, and Ukraine) subsequently eliminated their nuclear arsenals and joined the NPT as non-nuclear-weapons states. Moreover, most countries that embarked on peaceful nuclear energy programs also, at one time or another, seriously contemplated mil-

itary programs, and a number actively engaged in nuclear weapons research and/or development.[4] The overwhelming majority of these states, however, chose to abandon these military pursuits well before they yielded a nuclear weapon.

Although the NPT can be faulted for not having universal membership, it remains the most widely subscribed-to international accord in existence, with only four outliers: India, Israel, Pakistan, and the Democratic People's Republic of Korea. To be sure, two of these states are very populous; but they also represent a distinct minority of the international community. Significantly, parties to the NPT agreed voluntarily in 1995 to extend the Treaty indefinitely – a clear indication at the time of the value states attached to the Treaty.

One could place a number of other developments in the positive column of a nonproliferation ledger. They include: the steady growth of nuclear-weapon-free zones (NWFZs), which now cover the entire Southern Hemisphere; deep reductions over the past 10 years in the size of the nuclear arsenals of the two largest NWS; adoption by many NPT members of strengthened International Atomic Energy Agency (IAEA) safeguards in the form of the Model Additional Protocol; adoption of United Nations Security Council Resolution 1540, which mandates all states to put in place and enforce effective physical protection and export control measures related to weapons of mass destruction proliferation and terrorism; and new momentum on nuclear disarmament as a consequence of the "Road to Zero" Initiative by George Shultz, William Perry, Henry Kissinger, and Sam Nunn.

These positive nonproliferation developments should not obscure the pressing proliferation challenges the world faces today. They are a useful corrective, however, to the notion that the nonproliferation regime is on its last legs and that all that is required to topple it completely is a further NPT defection (read, Iran), which in fact would be only the second in the Treaty's history. They also direct attention to a significant aspect of the proliferation puzzle: what best accounts for the slow pace of nuclear weapons spread?

Much of the thinking about nuclear proliferation has been informed by the assumption that states seek nuclear weapons because their security in an anarchic world demands it. In its unadulterated form, this "realist" perspective discounts the impact of international institutions, norms, regime type, domestic politics, and personalities on nuclear decision-making; all that really matters is the balancing dynamic in which one state's pursuit of nuclear weapons begets another's. And yet this simple and elegant thesis is hard-pressed to account for the small number of nuclear weapons possessors, the slow pace of proliferation, and the abandonment of nuclear weapons activities by most states that initially chose to embark on them.

The Role of Alliances. In an effort to reconcile the discrepancy between realist assumptions and actual state behavior, it has been suggested that weak states may choose to rely temporarily on security guarantees from NWS in lieu of an indigenous nuclear weapons deterrent. This thesis is often cited to explain nuclear weapons abstinence on the part of many NATO members, as well as Japan, South Korea, and Taiwan. Secretary of State Clinton also has hinted that the United States might rely on this approach to dampen nuclear proliferation in the Middle East should

Iran move closer to a nuclear weapons capability.[5] Several recent studies, however, have cast doubt on the effect security guarantees have on nuclear restraint, even with respect to Japan, a NNWS usually cited as the model case. Etel Solingen, for example, argues persuasively that American guarantees do not adequately explain Japanese nuclear restraint. As she points out, during the post–World War II period there has been little correlation between the perceived reliability of the U.S. guarantee and the strength of Japanese interest in nuclear weapons. In addition, there were fears that the alliance might entangle Japan in U.S.-led initiatives that were not in its interest.[6] More generally, Solingen finds that "U.S. and Soviet commitments to client states (North Korea, Iraq, Israel, and Pakistan) did not lead these states to renounce nuclear weapons. Nor did the absence of security guarantees play any role in decisions by Egypt (1971), Libya (2003), South Africa, Argentina, or Brazil to reverse nuclear ambitions."[7]

The evidence presented by Solingen is not conclusive and is at odds with both conventional wisdom and several possible counterexamples. It is intriguing, however, that the few relevant quantitative publications on (non)proliferation correlates yield findings generally consistent with Solingen's thesis despite using different data sets and analytical techniques.[8]

The Power of Institutions. An alternative explanation of nuclear weapons restraint emphasizes the power of economics and institutions and is more optimistic about the prospects for accomplishing long-term cooperation among states. According to this view, the vast majority of states made a rational choice when they joined the NPT, surrendering their sovereign right to build nuclear weapons in exchange for the promise of material benefits, including the eventual disarmament by the NWS and the foreswearing of nuclear weapons by other NNWS.

Although most analysts agree that the NPT has reinforced nonproliferation tendencies, they are divided on the proposition that the Treaty has caused states that otherwise would have acquired nuclear weapons to abandon their pursuit. Jacques Hymans, for example, suggests that if the regime were to have played such a significant role, one might have expected far more proliferation prior to the emergence of the NPT as a widely subscribed-to treaty.[9] Similarly, Solingen finds that for the nine states she examines most choices to remain non-nuclear were made prior to, rather than as a consequence of, the decision to ratify the NPT. This was the case, she argues, for Japan, South Korea, and Taiwan. In addition, she points out that the NPT did not prevent Iran, Iraq, Libya, and North Korea from pursuing nuclear weapons subsequent to their adherence to the NPT.[10]

The critiques by Hymans and Solingen are useful in calling attention to the surprisingly scant body of empirical research on the relationship between international institutions and nuclear restraint. Both also raise legitimate questions about the relative explanatory power of NPT membership as opposed to other potential sources of nuclear restraint. One problem with their critiques, however, is the small number of cases upon which their arguments rest and their suitability for testing the proposition that the NPT had a marginal restraining effect. Although the evidence they extract from 13 states is suggestive, their argument would be more compelling if it were based on a broader set of countries in the post-NPT period.

A review of the small body of quantitative research on the subject offers additional reason for caution in assessing the impact of the NPT on national nuclear weapons decisions. Dong-Joon Jo and Erik Gartzke, for example, find that NPT membership has a marginal impact on nuclear weapons choice. NPT parties, they argue, are only slightly less prone to pursue nuclear weapons programs; but the inhibiting effect of the Treaty, they conclude, is offset by the technological diffusion it encourages.[11] In his analysis, Philipp Bleek discovers that while signing the NPT has no effect on whether or not states will initiate weapons programs, NPT parties that have initiated programs "are less likely to see them through to completion and acquire nuclear weapons."[12]

The Influence of Non-Material Incentives. Yet another way to view nuclear choice is to look beyond security considerations and to recognize that even "power politics" can be tempered by human practice. According to this perspective, under appropriate conditions the international social environment may foster the development of norms, institutions, and behavior conducive to states' renunciation of nuclear weapons.[13] From this vantage point, the NPT represents the embodiment of the international nonproliferation norm and has important symbolic value in addition to its promise of material benefits.[14]

Maria Rost Rublee's analyses of Japanese and Egyptian nuclear decision-making are very much in this tradition and suggest that the creation of the NPT not only had the effect of altering elite perceptions about the value of nuclear weapons, but also spawned commitments that "grew legs" in the form of supportive bureaucracies, budgets, and organizational power.[15] Although plausible, this interpretation is challenged by Etel Solingen, who examines a number of the same (and other) cases. According to Solingen's research, the operation of pragmatic considerations of a political-economic nature typically takes precedence over normative ones. Most of the 13 case studies prepared for the Center for Nonproliferation Studies (CNS) project on Forecasting Nuclear Proliferation in the 21st Century similarly provide little evidence that normative factors by themselves account for much variation in national decisions to acquire or forgo nuclear weapons.

Jacques Hymans's research on the demand side for the bomb also is relevant to an assessment of the power of non-material incentives. His approach is unusual, as it stresses neither the dampening effect that broad trends in international norms have on proliferation tendencies nor the corresponding constraints that may follow from societal pressures. Rather, his focus is on "deviant" oppositional nationalist leaders whose combination of fear and pride propels them down the nuclear weapons path. According to Hymans, the apparent success of the NPT in containing proliferation results primarily from the fact "that few state leaders have desired the things it prohibits."[16]

Approaches that emphasize normative influences on nuclear decision-making often are criticized for their lack of clarity in explaining how, when, and why norms influenced nuclear weapons decisions. One of the few studies to tackle this issue directly is by Harald Müller and Andreas Schmidt. Their research points to a decline after 1960 in the number of states with nuclear weapons activities relative to the total number of states in the international system, a trend the authors attribute in part to a shift in the global norm regarding nucle-

ar nonproliferation. The authors attach particular importance to the unanimous adoption, in 1961, of a resolution introduced by Ireland to the United Nations General Assembly. The resolution called upon all members to conclude an international agreement prohibiting states not possessing nuclear weapons from acquiring them and states with nuclear weapons from assisting other members in their manufacture or acquisition by other means.[17] According to Müller and Schmidt:

> For states that gained their independence late (after the Irish Resolution), being non-nuclear was seen as an appropriate status, the attribute of a "good citizen" of the world community of states. For the "old states," the new norm competed with the old understanding that a state was entitled to acquire armament according to the standard of the time. This is an indication . . . that the debate and codification of a new, though yet weak international norm had an impact upon the way the new states viewed proper behavior and shaped their own understanding of security. For the old states, the impact was weaker, but the series of terminations of nuclear weapons activities started during that period. In 1968, a much stronger norm was created: the Nuclear Nonproliferation Treaty.[18]

An alternative interpretation of "when and why" that de-emphasizes the role of norms is provided by Christopher Way and Karthika Sasikumar in what is arguably the most carefully crafted aggregate data analysis of when and why states join the NPT.[19] Assuming that states rely on cost-benefit analysis when choosing whether or not to accede to the NPT, the authors employ event-history models and a variety of economic, security, and political indicators for the 1968 to 2000 time period to assess the power of alternative explanatory variables. They conclude, among other things, that those states that enjoy benign security environments or for whom developing nuclear weapons would be technologically or economically difficult sign on relatively quickly, while those paying higher opportunity costs in giving up the nuclear option are more likely to be NPT laggards.[20]

The Force of Domestic Politics. A growing body of research suggests that one cannot properly understand nuclear weapons restraint without reference to the domestic context in which nuclear decisions are made. Indeed, the interplay of bureaucratic politics, organizational processes, and individual personalities may be more consequential in shaping proliferation outcomes in a number of states than the threats emanating from the international security environment. As Scott Sagan points out, from this vantage point "[t]he NPT regime is not just a device to increase states' confidence about the limits of their potential adversaries' nuclear programs; it is a tool that can help to empower domestic actors who are opposed to nuclear weapons developments."[21]

The most persuasive evidence about the force of sub-national dynamics in explaining nuclear outcomes is marshaled by Etel Solingen, who emphasizes the importance of the domestic ruling coalition's orientation to the global political economy. Nuclear weapons programs, she argues, are less likely to emerge in countries when the domestic political landscape is sympathetic to economic openness, trade liberalization, foreign investment, and international economic integration. This thesis largely is borne out in her comparative analysis of nine states from East Asia and the Middle East, which also finds that NPT considerations were not central to the nuclear

renunciation decisions of these countries.

Findings from my own research on nuclear decision-making in Belarus, Kazakhstan, and Ukraine following the collapse of the Soviet Union offer qualified support for Solingen's thesis, and also suggest that the NPT was only a secondary factor influencing nuclear reversal decisions.[22] Solingen's model fits best with Ukraine, where the main threats to the country's territorial integrity were seen by the key political players as domestic rather than external. These acute dangers were in the form of economic collapse and Crimea's attempt to assert its independence from Ukraine – threats unlikely to be mitigated by nuclear weapons. Moreover, there was recognition in Kyiv, reinforced by U.S. policy, of the connection between Ukraine's nuclear policies and its access to foreign capital and technology. In Kazakhstan, the linkage was less direct and the perceived threats also were much less urgent. As a consequence, Kazakhstani policy-makers were in no hurry to denuclearize and were aware that the weapons on their territory might have practical value as bargaining chips related to a variety of economic, environmental, and security needs. The leadership, however, was very pragmatic and was receptive to the U.S. argument that the future of the country's peaceful nuclear energy program was dependent upon its non-nuclear-weapons status. Solingen's thesis works least well in the case of Belarus, whose president, Stanislav Shushkevich, saw little value in a Belarusian nuclear force even if it could be afforded. His attitude appears to have had little to do with international economic considerations, but instead reflected his professional training as a nuclear physicist and view of nuclear weapons as immoral and unnecessary.

As the preceding discussion indicates, the scholarly literature on nuclear weapons decision-making, including the small body of relevant quantitative studies, is divided on the importance one should attribute to the NPT in explaining past nuclear weapons renunciation decisions. Although a number of country analyses touch on the role played by the NPT in individual cases, surprisingly few studies focus specifically on the topic. Instead, NPT advocates and critics alike typically assert their preferred views about the merits of the Treaty and its (in)dispensable contribution in retarding the spread of nuclear weapons.

The period during which the NPT received the most sustained attention was the five-year run-up to the 1995 NPT Review and Extension Conference. At that time it was by no means assured that the Treaty would be extended indefinitely, and a number of analyses were undertaken to assess how the demise of the NPT might affect the international nonproliferation scene. Particularly noteworthy was a collection of essays on *Beyond 1995: The Future of the NPT Regime*.[23] In one of the book's most cogent contributions, Lawrence Scheinman sums up the prevailing view of scholarly thinking at the time, which does not differ markedly from the present: *the NPT alone cannot and does not prevent proliferation*. As he notes, "Studies of national decisions on acquiring nuclear weapons or acceding to the NPT . . . show that in virtually every case the decision made can be explained by reference to something other than the NPT – either to domestic considerations, the impact of acquiring nuclear weapons on bilateral relations, assessment of technological limitations, political costs, or security consequences."[24] To paraphrase Scheinman's conclusions: Does this

mean that the NPT doesn't matter? No. Would its demise negatively impact efforts to contain proliferation? Yes. Would the nonproliferation norm, international safeguards, and general nonproliferation restraint continue in the absence of the NPT? Perhaps. In short, according to Scheinman, "the NPT is a necessary but not sufficient condition for nonproliferation"; it may not prevent proliferation, but it significantly impacts the nuclear decision-making environments in many countries.[25]

Scheinman's essay also highlights the various nonproliferation roles played by the NPT and the logic of assessing the value of the Treaty in terms of the importance one attaches to these different functions. For example, it is useful to distinguish among the NPT's roles as a legal barrier, a normative standard, and a confidence-building measure. The latter function, which may be less obvious than the others, includes important international safeguards commitments that states party to the NPT are obliged to undertake. These commitments are legally binding and entail verification procedures designed to reassure other states about the peaceful uses of a country's nuclear activities. Although international safeguards and the confidence they instill are not dependent on the NPT, it is extremely doubtful if a global system of stringent safeguards approaching those currently in existence would have developed in the absence of the NPT.[26]

Many nonproliferation analysts maintain that the NPT, as a multilateral treaty, has some constraining effect on states party to the Treaty. As Scheinman argues, "Formalized commitments containing reciprocal obligations establish thresholds that are more difficult to cross."[27] This assessment is logical in terms of the psychological, bureaucratic, and domestic political obstacles that treaties impose notwithstanding their withdrawal clauses. And indeed, most research on international treaties suggests that states generally comply with the accords they conclude. Less clear-cut, however, is the extent to which states comply because of any legal commitment to do so or because of the conditions that prompted them to sign the treaty in the first place.[28] Based on the aggregate data analysis of Way and Sasikumar and a number of country-specific case studies, especially those by Rublee, the NPT would appear both to constrain and screen.

One of the most unusual aspects of the 1995 NPT Review and Extension Conference was the near unanimity among more than a hundred national statements during the first week of general debate about the benefits of the NPT for the specific states in question. These statements were by no means uniform and made reference to a variety of arguments ranging from reduced regional arms racing, increased confidence in the peaceful intentions of potential adversaries, progress in promoting disarmament among the NWS, expansion of NWFZs, harnessing of the atom for peaceful use, and the promise of greater peace and stability in the international system. Although these statements emphasized different points and perspectives, what was striking to this observer was the general consistency of the message that the NPT was, net, a significant plus and should be extended (either indefinitely or for a long duration), as well as the apparent heartfelt manner in which many of the statements were delivered.[29]

Today the rhetoric about the value of the Treaty as reflected in national state-

ments in the NPT review process remains much the same. Nevertheless, one has the impression that many of the speakers are simply going through the motions, reiterating past declarations about the importance of the Treaty, but without much passion or conviction. This lackadaisical approach to the business of the NPT, aptly described by former UN Secretary General Kofi Annan as "sleep walking," was most apparent at the 2005 NPT Review Conference, which finished early without any substantive result. It was almost as if the heads of delegations (mostly Conference on Disarmament ambassadors) were anxious to catch an early flight back to Geneva or otherwise beat the traffic home.

One probably should not attach much importance to this very unscientific and impressionistic observation of diplomatic sentiment regarding the state of the nonproliferation regime. Even a cursory comparison of today's nonproliferation scene with that of 1995, however, suggests the need to view nonproliferation in dynamic terms and to examine, if only briefly, how the regime may have changed in recent years and how evolving international developments may alter the future effectiveness of the NPT as a means of nuclear restraint. Although one can identify many changes, three of the most important pertain to the growth of non-state actors as proliferation threats, the diminished benefits of NNWS status under the NPT in the aftermath of the U.S.-India nuclear deal, and the increased centrality of Article IV (peaceful use) provisions in many states' assessments of the benefits and limitations of the NPT.

Non-State Actors. At the time the NPT was negotiated, little attention was given to the proliferation risks posed by non-state actors, either as suppliers of sensitive nuclear material, technology, and know-how or as end-users (that is, parties who sought to acquire and use nuclear weapons). As a consequence, the NPT did not seek to address the potential risks of nuclear terrorism posed by non-state actors, and steps to remedy this oversight recently have been introduced in a variety of multilateral, bilateral, and unilateral initiatives, only some of which represent legally binding mechanisms.[30] Although it remains to be seen how effective these new initiatives will be in forestalling efforts by non-state actors to act as nuclear suppliers, middlemen, and end-users, it is apparent that the provisions of the NPT per se are not well suited to address either the supply or demand side of the nuclear terrorism equation. As such, one should not expect the NPT to serve as a major source of nuclear weapons restraint for non-state actors, even as such entities emerge as a growing proliferation risk.[31]

The U.S-India Nuclear Deal. One of the major benefits of NPT membership for NNWS is the promise of access to equipment, materials, and scientific information for the peaceful use of nuclear energy. In return, NNWS pledge to place all of their nuclear facilities under IAEA safeguards and to refrain from pursuing nuclear weapons activities. It is this core bargain that has been used to good effect by advocates of nuclear restraint – typically "outward looking elites," to use Solingen's terminology – in a number of countries. Although the long-term effects of the U.S.-India nuclear deal and the associated exemption granted to India by the Nuclear Suppliers Group in 2008 remain to be seen, almost certainly they will include an erosion of the perceived value of NNWS membership in the NPT. Indeed, representatives from a number of relatively recent adherents

to the NPT have expressed the view privately that had their governments anticipated that a non-NPT state and nuclear weapons possessor would be so rewarded, they would have hesitated to join the Treaty.[32] The readiness on the part of NPT states-parties to willfully ignore politically binding pledges made at the 1995 NPT Review and Extension Conference to refrain from nuclear trade with states lacking comprehensive safeguards also can only undermine the nonproliferation norm and provide ammunition for institutional advocates of revisiting the value of the NPT for their country's economic, political, and security interests.[33]

Article IV. The most contentious article of the NPT during most of its existence has been Article VI, which commits parties to the Treaty to pursue disarmament negotiations in good faith. At most NPT Review Conferences, for example, the greatest division among states and the most difficult issue on which to forge consensus has involved progress – or the lack thereof – on nuclear disarmament. It is unlikely that the gulf separating NWS and NNWS over implementation of Article VI will disappear soon, although the readiness of the new U.S. administration to embrace the vision of nuclear disarmament can only be helpful in this regard. There are indications, however, that it may prove even more difficult in the future to build consensus on issues related to peaceful use than on disarmament, as many current nuclear exporting states insist upon more stringent safeguards on nuclear use (for example, adoption of the Additional Protocol to the IAEA as a condition of export) and limitations on the further spread of sensitive nuclear fuel-cycle activities. These proposed measures, designed to address misuse of peaceful-use provisions for military purposes, are regarded by a number of key NNWS, and especially Non-Aligned Movement (NAM) members such as Egypt and South Africa, as a restriction on their "inalienable right" to peaceful nuclear use as expressed in Article IV. Although it is possible that meaningful progress on the disarmament front may yield more flexibility by NAM on peaceful-use measures related to export controls and safeguards, this development is by no means certain, and it is probably as likely that a number of states will continue to decry these nonproliferation efforts as an erosion of their NPT rights and as evidence of further backtracking on the NPT grand bargain. Should this development occur, it will contribute to the weakening of the perceived value of the NPT for many NNWS and the possible decision by some states under certain circumstances to reconsider their adherence to the Treaty, even if they have no nuclear weapons ambitions.

The tension between satisfying the demands of NNWS for peaceful nuclear use and the insistence by NWS, among others, on more prudent nonproliferation and counterterrorism behavior is apt to grow if the projected "nuclear renaissance" materializes. Under such circumstances, many more states with underdeveloped nuclear regulatory bodies and stunted nuclear security and safety cultures will gain access to nuclear material, technology, and technical know-how, with dual applications for military and peaceful purposes. This development has the potential both to undermine the NPT and also to make it and its associated IAEA nonproliferation safeguards regime more important.

The aforementioned trends may well hinder the future effectiveness of the NPT. Nevertheless, does it follow that the conventional wisdom is correct and

that we are on the cusp of a "tipping point" after which we should anticipate a new wave or chain of proliferation decisions?

One of the difficulties in making accurate prognoses about the future of nonproliferation is the underdeveloped state of research on foreign policy forecasting in general and nuclear decision-making in particular. Also contributing to the problem is the paucity of relevant theory with predictive value. In an effort to remedy this proliferation-knowledge deficit and to better gauge the prospects for nuclear weapons spread during the next decade, CNS undertook a study of the proliferation propensity of 13 countries from different regions of the world.[34] The project also sought to assess the impact of various trigger events, including defections from the NPT, on national nuclear decisions.

The project's most significant and unanticipated finding with respect to proliferation propensity, and one that was evident across all of the case studies, is the relatively low expectation of proliferation during the next 10 years. This prognosis holds regardless of the theoretical approach and level of analyses favored by the analyst, and appears to be largely insensitive to the geographic location of the countries, their level of economic development, government type, and perceived external security environment. While surprising in terms of prevailing conventional wisdom about a pending proliferation pandemic, the results, in fact, are consistent with the historically slow pace of proliferation and the failure of most prior forecasts of proliferation doom to materialize. They also are compatible with the theories of nuclear choice espoused by Hymans and Solingen that point to the exceptional circumstances that must pertain in order for states to abandon nuclear restraint.

In addition, the project found that there is little evidence of the operation of "reactive proliferation," in which one state's efforts to acquire nuclear weapons will prompt a reciprocal response by others. Case study authors, for example, were disinclined to regard weaponization by any single country itself as sufficient to reverse long-standing nonproliferation restraint on the part of most other countries, including Egypt, Japan, Saudi Arabia, Serbia, South Africa, South Korea, Syria, Turkey, Ukraine, and Venezuela.[35] Significantly, this finding applies even when the "trigger" is Iranian defection from the NPT.

Moreover, to the extent that one country's proliferation decision has a near-term diffusion effect, it appears to be very context-dependent and requires a number of other circumstances to occur. Among the effects dampening the potential operation of a proliferation chain is the fact that nuclear decisions take place in a domestic political environment sensitive to considerations of a political-economic nature, as well as competing organizational interests and personalities.

Although one may interpret the general finding – that an Iranian defection from the NPT would have a limited impact on individual country futures – as an indication of the strength and vitality of the Treaty, an alternative interpretation is that the Treaty is less central to the nuclear orientation of some states than is often assumed to be the case. This perspective appears to be borne out in the case studies of Australia, Iran, Syria, Venezuela, and Yugoslavia (post-1974). Nevertheless, a number of the project's other case studies, including those of Japan, South Africa, South Korea, Turkey, and Ukraine, highlight

the significant – if indirect – positive effect the NPT has on nuclear weapons restraint by reinforcing the position of institutional advocates for nuclear abstinence in domestic political debates. The Treaty also continues to have a symbolic normative value in many of the countries surveyed, and elites in states such as Australia, Japan, South Africa, South Korea, and Ukraine regard adherence to the NPT as an integral part of their credentials as members of the international community in good standing.

The findings from the forecasting project indicate that it is premature to anticipate a world of many nuclear weapons possessors, at least in the near term. It is also not constructive to dismiss the utility of the NPT even if it is difficult to demonstrate conclusively the existence of a cause and effect relationship between the Treaty and nuclear weapons restraint. In this regard, it was refreshing to hear President Obama declare in Prague in April 2009 that the spread of nuclear weapons is not inevitable and that states can and must undertake concrete steps to strengthen the NPT, whose basic bargain remains sound.[36] This view is an important counterpoint to the fatalism inherent in a number of nuclear proliferation chain scenarios popular today, but also cautions against complacency.

A recent book by two former government officials with access to many nuclear secrets likens the current nonproliferation scene to a speeding express train driven by indifferent engineers and filled with fissile material, nuclear technology, and sleeping passengers.[37] The imagery is powerful and the metaphor may yet prove apt. On the other hand, the proliferation train has been slow to pick up steam, has made fewer stops than anticipated, and usually has arrived much later than expected. More likely than not, the NPT has helped to slow the engine of proliferation. Additional action will be needed, however, to wake up some of the passengers, inspire and inform the engineers of U.S. nonproliferation policy, and delay further the departure of the nuclear express.

ENDNOTES

[1] This essay benefits greatly from collaboration with Gaukhar Mukhatzhanova, who assisted me on a research project on Forecasting Nuclear Proliferation in the 21st Century. The author also is grateful for research assistance provided by Liviu Horowitz. The interpretations expressed below, however, are my own.

[2] See, for example, Howard Simons, "World-Wide Capabilities for Production and Control of Nuclear Weapons," *Dædalus* 88 (3) (Summer 1959): 385–340; Oskar Morgenstern, "The Nth Country Problem," *Fortune* (March 1961): 136; Lewis A. Dunn and Herman Kahn, *Trends in Nuclear Proliferation, 1975–1995*, Final Report to the U.S. Arms Control and Disarmament Agency (Washington, D.C.: Hudson Institute, May 15, 1976).

[3] "Weapons Production in Fourth Countries: Likelihood and Consequences," National Intelligence Estimate, No. 100-6-57 (Washington, D.C.: National Security Archive, June 18, 1957).

[4] Harald Müller and Andreas Schmidt calculate that 36 states have had "nuclear weapons activities since the beginning of the nuclear age." See Müller and Schmidt, "The Little Known Story of De-Proliferation: Why States Give Up Nuclear Weapon Activities," in *Forecasting Proliferation: The Role of Theory*, ed. William C. Potter (with Gaukhar Mukhatzhanova) (Stanford, Calif.: Stanford University Press, forthcoming, 2010).

[5] See Mark Landler and David E. Sanger, "Clinton Speaks of Shielding Mideast From a Nuclear Iran," *The New York Times*, July 23, 2009.

[6] Etel Solingen, *Nuclear Logics: Contrasting Paths in East Asia and the Middle East* (Princeton, N.J.: Princeton University Press, 2007).

[7] Ibid., 25.

[8] See, for example, Dong-Joon Jo and Erik Gartzke, "Determinants of Nuclear Weapons Proliferation," *The Journal of Conflict Resolution* (February 2007): 167–194; Sonali Singh and Christopher R .Way, "The Correlates of Nuclear Proliferation: A Quantitative Test," *The Journal of Conflict Resolution* (December 2004): 859–885; and Philipp C. Bleek, "Why Do States Proliferate?" and Müller and Schmidt, "The Little Known Story of De-Proliferation," both in *Forecasting Proliferation*, ed. Potter.

[9] See Jacques Hymans, *The Psychology of Nuclear Proliferation: Identity, Emotions, and Foreign Policy* (New York: Cambridge University Press, 2006), 6.

[10] See Solingen, *Nuclear Logics*, 261–267.

[11] Jo and Gartzke, "Determinants of Nuclear Weapons Proliferation," 185.

[12] Bleek, "Why Do States Proliferate?" in *Forecasting Proliferation*, ed. Potter, 30.

[13] In the international relations theory literature this orientation is referred to as "constructivism."

[14] See, for example, Maria Rost Rublee, *Nonproliferation Norms: Why States Choose Nuclear Restraint* (Athens: University of Georgia Press, 2009).

[15] Ibid., 130–132.

[16] Hymans, *The Psychology of Nuclear Proliferation*, 7.

[17] Müller and Schmidt, "The Little Known Story of De-Proliferation," in *Forecasting Proliferation*, ed. Potter, 247. On the "Irish Resolution," see William Epstein, *The Last Chance: Nuclear Proliferation and Arms Control* (New York: Free Press, 1976), 62–63.

[18] Müller and Schmidt, "The Little Known Story of De-Proliferation," in *Forecasting Proliferation*, ed. Potter, 249–250.

[19] Christopher Way and Karthika Sasikumar, "Leaders and Laggards: When and Why Do Countries Sign the NPT," REGIS Working Paper No. 16 (Montreal: University of Montreal/McGill University, November 2004).

[20] Ibid., 28.

[21] Scott D. Sagan, "Why Do States Build Nuclear Weapons? Three Models in Search of a Bomb," *International Security* (Winter 1997): 72.

[22] William C. Potter, *The Politics of Nuclear Renunciation: The Cases of Belarus, Kazakhstan, and Ukraine*, Occasional Paper No. 22 (Henry L. Stimson Center, April 1995), and Potter, "Back to the Future: The Contemporary Relevance of the Nuclear Renunciation Decisions by Belarus, Kazakhstan, and Ukraine," Nobel Symposium, Oscarborg, Norway, June 25–27, 2009.

[23] Joseph F. Pilat and Robert E. Pendley, eds., *Beyond 1995: The Future of the NPT Regime* (New York: Plenum Press, 1990).

[24] Lawrence Scheinman, "Does the NPT Matter?" in *Beyond 1995*, ed. Pilat and Pendley, 61.

[25] Ibid., 54–55. For similar assessments, see the contributions by Lewis Dunn, "The Collapse of the NPT – What If?" and David Fischer, "What Happens if the NPT Goes?" in *Beyond 1995*, ed. Pilat and Pendley.

[26] A number of NWFZs require parties to adhere to comprehensive safeguards without reference to the NPT.

[27] Scheinman, "Does the NPT Matter?" in *Beyond 1995*, ed. Pilat and Pendley, 55.

[28] A budding literature in political science has emerged that explores potential section bias in treaty behavior and seeks to determine if treaties primarily "constrain" or "screen." Compare, for example, Jana von Stein, "Do Treaties Constrain or Screen? Selection Bias and Treaty Compliance?" *American Political Science Review* (November 2005): 611–622, and Beth Simmons and Daniel Hopkins, "The Constraining Power of International Treaties," *American Political Science Review* (November 2005): 623–631.

[29] The author participated in the 1995 NPT Review and Extension Conference as a technical advisor to the delegation of Kyrgyzstan, and has participated in a similar capacity in every subsequent Review Conference and Preparatory Committee meeting.

[30] For a discussion of some of these initiatives, see Charles D. Ferguson and William C. Potter (with the assistance of Amy Sands, Leonard S. Spector, and Fred Wehling), *The Four Faces of Nuclear Terrorism* (New York: Routledge, 2005), 318–335; Michael Levi, *On Nuclear Terrorism* (Cambridge, Mass.: Harvard University Press, 2007), 139–152; and Matthew Bunn, *Securing the Bomb 2008* (Cambridge, Mass.: Project on Managing the Atom, Harvard University, November 2008), 129–185.

[31] One area in which the NPT might help to constrain nuclear terrorism is to discourage the use of highly enriched uranium in the civilian nuclear sector, a focal point for discussion in Main Committee III (on peaceful nuclear use) at the 2005 NPT Review Conference. Unfortunately, a number of NNWS perceive such action as restricting their "inalienable right" to peaceful nuclear use.

[32] Communications to the author at meetings of the IAEA General Conference in 2007 and 2008.

[33] This reassessment would be further encouraged should India be recognized as a *de jure* NWS. Japan, among other states party to the NPT, has indicated that it would need to reevaluate the role of the NPT in its national security policy should any country beyond the original NWS be so recognized by the international community.

[34] Case studies were undertaken for Australia, Egypt, Iran, Japan, Saudi Arabia, Serbia, South Africa, South Korea, Syria, Taiwan, Turkey, Ukraine, and Venezuela.

[35] The authors of the case study of Australia were less sanguine about the impact of militarization of Japan on the nuclear calculus in Canberra.

[36] Remarks by President Barack Obama in Prague, April 5, 2009.

[37] Thomas C. Reed and Danny B. Stillman, *The Nuclear Express: A Political History of the Bomb and Its Proliferation* (Minneapolis, Minn.: Zenith Press, 2009), 319.

Atsuyuki Suzuki

Toward a robust nuclear management system

This essay outlines a path toward a robust nuclear management system, a prerequisite if nuclear power is to play a significant role in creating a globally sustainable energy future. What do I mean by a robust nuclear management system? Looking back at the history of nuclear power development over the last 50 years, the nuclear industry was not able to obtain a wide range of public support, as originally expected; current achievements are not necessarily faring much better. The Three Mile Island accident in 1979 and the Chernobyl accident in 1986 had a severe impact on the level of public support for nuclear energy; both accidents were serious enough for people to feel extremely uneasy about the use of nuclear energy. The second issue that has contributed to global apprehension about nuclear power development is the fact that nuclear proliferation concerns have not diminished, but rather, have expanded as states continue to pursue nuclear weapons programs and as risks of non-state actors obtaining nuclear materials continue to increase. Managing the spent fuel from nuclear power production is closely related to safety and security issues because it contains plutonium as well as highly radioactive materials. Global concern over spent fuel management has been increasing as the amount of spent fuel has risen worldwide.

A robust nuclear management system must address at least these concerns – safety, security, and nonproliferation – in order to minimize anxieties among the public, nationally and internationally, regarding the widespread use of nuclear energy. A robust system is necessary for the global community to enjoy the dividends expected from using nuclear power for civilian purposes. The crucial question is how to create such a robust system. It is an enormous challenge; nonetheless, in light of current constraints on energy worldwide, my view is that it is necessary. Nuclear power has the potential to be a major energy source, meeting the base-load electricity demands anticipated in rapidly growing economies. Energy is, in many ways, an essential underpinning for future economic and social progress. At the same time, demands for energy need to be balanced with concerns about the environmental impacts of producing and using energy, particularly the emissions of pollutants into the atmosphere. Nuclear power provides an alternative source to

meet energy demands in a substantially carbon-free manner.

This essay explores the ways in which comprehensive safety management with improved social communication and accountability for nuclear power development, complemented by transparency and international cooperation, can contribute to a robust system that addresses safety concerns, public anxieties, and nonproliferation issues. By sufficiently tackling these issues, the global community will be able to reap the benefits of nuclear power – namely, its contributions to mitigating carbon dioxide emissions and to fulfilling global energy demands.

To consider whether nuclear energy can play an important role in meeting the global demand for carbon-free energy, one must look at the long-term perspectives and imagine possible global nuclear energy scenarios for the year 2050. The 2003 MIT study, *The Future of Nuclear Power: An Interdisciplinary Study*,[1] attempts to imagine some of these scenarios. The study projects that 1,000 GWe of nuclear power capacity will be required in 2050, with regional estimates of 300, 210, 115, 50, 200, 75, and 50 GWe for, respectively, the United States; Europe and Canada; developed East Asia (Japan, Korea, and Taiwan); the former USSR; China, India, and Pakistan; Indonesia, Brazil, and Mexico; and others. Similarly, in 2008 the Organisation for Economic Co-operation and Development (OECD), via its Nuclear Energy Agency (NEA),[2] put forth a low and a high projection for 2050: 580 GWe and 1,400 GWe, respectively. This study emphasizes that current nuclear capacity would increase by more than 1,000 GWe for the high scenario and by more than 200 GWe for the low scenario. The OECD's International Energy Agency (IEA) projections from 2006 give the more moderate figure of about 900 GWe for the high scenario,[3] while the 2007 Intergovernmental Panel on Climate Change (IPCC) estimates the high scenario to be slightly lower than 1,400 GWe.[4]

The 2003 MIT projection of 1,000 GWe of nuclear power capacity for 2050 seems appropriate. However, given that more than 50 percent of the world's population lives in the Asian region, a slight modification is necessary. Looking at projections made by China and India alongside the actual national energy strategies pursued by these countries, the long-term energy demand in both China and India apparently requires much more nuclear energy than noted in the MIT projection. One of China's projections[5] predicts total electricity demand in 2050 to be about 1,600 GWe, approximately three times as much as in 2000, or roughly two-and-a-half times as much as the current level. Taking population growth into account, this projection appears quite reasonable. The configuration of the energy sources, however, is problematic. The projection requires 950 GWe of coal-fired generation in 2050, which is about two-and-a-half times the current level. The amount of nuclear energy for 2050 is projected to be 250 GWe, which is about 10 times the current level. If this becomes the case, carbon dioxide emissions will likely be more severe due to heavy reliance on coal power. Nuclear capacity of 250 GWe would be a minimum if the nuclear option is to play a significant role in Chinese contributions to solving global warming issues and reducing carbon dioxide emissions.

India's situation is similar. A 2004 Indian government study[6] states that the total electric energy demand in 2050 will

be about 1,300 GWe, with roughly 600 GWe from coal and 250 GWe from nuclear. Considering the economic growth rate anticipated in India, this projection appears realistic, suggesting that a nuclear capacity of 250 GWe will be necessary to compensate (albeit slightly) for the increase in the quantity of carbon dioxide released from coal-fired electricity production in India. Thus the nuclear power needed in China and India in 2050 should be projected to be at least 500 GWe, rather than 400 GWe as estimated in the 2003 MIT study.

The MIT team recently updated the study,[7] saying, "With regard to nuclear power, while there has been some progress since 2003, increased deployment of nuclear power has been slow both in the United States and globally, in relation to the illustrative scenario examined in the 2003 report." Compared to 2003, they noted, "the motivation to make more use of nuclear power is greater, and more rapid progress is needed in enabling the option of nuclear power expansion to play a role in meeting the global warming challenge." The team concluded, "The sober warning is that if more is not done, nuclear power will diminish as a practical and timely option for deployment at a scale that would constitute a material contribution to climate change risk mitigation."

I agree with this observation, and the 2003 MIT projections for developed nations such as the United States, Europe and Canada, and developed East Asia would be modified to be less. For example, in this case, nuclear power in the United States would not be 300 GWe, but 200 GWe. Thus, the global nuclear power scene in 2050 will be entirely different from the current scene. The amount of nuclear electricity in developing nations would be nearly the same as the amount in developed nations (say, 500 GWe for each), and in terms of capacity in individual nations, China and India would be the leading countries, possibly surpassing the United States or Europe and Canada unless more is done in those regions.

A world where China and India are the champions of nuclear power production would be a totally different playing field as far as the world nuclear regime and the world nuclear industry go. Thus, and returning to the original premise of this paper – how to develop a robust nuclear management system – the architecture of that system should be designed with the assumption that a number of new entrants will operate their own nuclear power plants and that China and India will have the greatest nuclear power production. In other words, a robust nuclear management system must recognize that the total amounts of nuclear electricity in developing nations will be greater than or at least comparable to the amounts in developed nations.

The evolution and improvement of safety management will be crucial to our nuclear future. How is safety best managed in a world where nuclear power expands remarkably in developing countries, and also spreads to a number of new entrants that construct and operate their own nuclear reactors? Nuclear energy can play an important role worldwide only when nuclear power development and reactor operation is safe, with no concerns about serious accidents. The challenge for us is to create a safer global nuclear option.

A robust nuclear management system, in which all countries are granted the right to use nuclear energy for civilian purposes, needs to emphasize the development of comprehensive safety

management. To this end, safety standards, as a minimum requirement, must be implemented on an international basis. In particular, any nuclear country will have to follow safety obligations to ensure that no accidents with serious consequences take place. Every nuclear power nation is, to a large extent, hostage to the safety performance in other nuclear power nations by virtue of the adverse consequences that would arise from a serious nuclear accident. Therefore, only countries capable of meeting comprehensive, international safety management norms should be in a position to utilize nuclear power.

How should the world pursue comprehensive safety management? More particularly, how can nations currently utilizing nuclear energy maintain and advance safety management, and how should nations developing nuclear power programs build on and utilize the safety management practices currently in place in nations with developed nuclear power infrastructures? First, the defense-in-depth concept is employed within the nuclear safety area to lessen the frequency of trigger events; to prevent them from leading to more severe events; and to mitigate the consequences, if they occur. Except for the Chernobyl accident, this defense-in-depth concept has contributed significantly to the avoidance of serious consequences within the nuclear industry. The usefulness of this concept should not be understated, but it could benefit from further strengthening. The concept, together with multiple physical barriers, should be advanced with some additional requirements for accident-management tools, which have been increasingly demanded in the aftermath of the Three Mile Island and the Chernobyl accidents.

Looking at the experiences over the past few years, however, it is clear that defense-in-depth, even with accident management tools, has not been sufficient because defenses can deteriorate as time passes. This realization is one of the most instructive lessons learned from the history of nuclear safety: that technical/engineering systems are inclined to age, and thus face diminished effectiveness in safety performance. Furthermore, human factors have also contributed to lapses in safety.

To compensate for such deficiencies, quality management systems have been increasingly developed to ensure consistent safety performance and quality of human operations. As a result of increased focus on quality management and a defense-in-depth concept complemented by proper accident management tools, nuclear safety is now well managed. With an appropriate combination of the above-mentioned measures, nuclear safety as a whole has been maintained successfully to date, and many countries with nuclear power programs have shown excellent safety performance over the last couple of decades.

This record of excellence is due not only to the application of technical/engineering systems, but also largely to interaction with society. Regulatory systems have been improved over time, and these improvements have been based significantly on society's demands for elevated nuclear safety. This societal aspect of nuclear safety is sometimes perceived as a "stakeholder's involvement" issue. A more robust nuclear system would include a more structured relationship between nuclear safety and society, to maintain the safety scheme in a way that encourages timely detection of deterioration in technical/engineering measures.

The effectiveness of any such detection system will depend greatly on how much accountability the people request from operators and regulators.

The social system required for safety management is critical. There is a variety of stakeholders, and no one stakeholder should dominate. However, related stakeholders should work together to reach consensus through an interactive communication process. A safety management system must incorporate substantive and procedural aspects, and thereby would be perceived as a more democratic process. In the social sciences, this process is interpreted as a "communicative action" in the public sphere, advocated by German philosopher Jürgen Habermas,[8] a well-known scientist insisting on the emergent need to facilitate communication between specialists, professionals or technocrats, and the general public.

I believe that a part of sustainable nuclear development is ensuring that every nuclear country creates its own communication system that enables all related stakeholders or sectors to participate. Communicative actions are essential to maintain and enhance safety for two reasons. One is transparency, which is not merely openness or information disclosure, but more importantly, accountability to the public, complemented with feedback on safety measures. The second reason is flexibility, as social requirements for safety change with time, depending on an operator's past safety performance or how often troubles and incidents have occurred.

This type of communication system is employed not merely in the nuclear safety area but in many other fields as well. A well-known American social scientist, Nobel laureate Herbert Simon, argued in his seminal book *The Sciences of the Artificial*[9] that we need to pay greater attention to so-called procedural rationality, rather than substantive rationality. Simon writes:

> Economics illustrates well how outer and inner environment(s) interact and, in particular, how an intelligent system's adjustment to its outer environment (its substantive rationality) is limited by its ability, through knowledge and computation, to discover appropriate adaptive behavior (its procedural rationality).[10]

Simon's ideas apply to nuclear safety management. The inner system – that is, the defense-in-depth concept, with quality management – is owned by an individual operator or regulator and needs to adjust to its outer environment; the ability to do so, however, is unfortunately limited. Only through improved knowledge obtained from communication between nuclear energy's inner and outer environments can appropriate adaptive behavior be promoted.

Undoubtedly, there is no absolute safety. The defense-in-depth concept, with quality management, is designed to help make up for any safety deficiencies in individual parts of the system. Looking at nuclear history, it has worked well. With regard to the goal of sustainable nuclear development, however, more than traditional measures need to be employed. According to Simon's suggestion, to rest only on the rationality invented in the inner environment is inherently limited. What would be better is to communicate with the outer environment and thereby discover appropriate, adaptive behavior. In other words, nuclear operators and regulators should actively communicate with the broader society, particularly with the local communities and others affected by and interested in the development of nuclear power.

The most important factor in such communication is transparency because, on the one hand, it is tremendously helpful for confidence-building in society and, on the other hand, it gives good incentives for operators and regulators to improve safety performance. As an analogy with the Simon's theory, this type of interaction between the inner and outer environments brings about procedural rationality, which might significantly strengthen or complement substantive rationality (that is, resting on the defense-in-depth concept, with quality management).

Safety management based on procedural rationality together with substantive rationality has been developed in advanced nuclear power countries, and as a result, safety performance in those countries has been enhanced remarkably. The same type of management must be employed in countries new to nuclear power, if the nuclear option is to be robust in terms of safety.

Managing spent nuclear fuel is an additional critical issue for nuclear power development because of both public concerns about safety and concerns regarding nonproliferation and terrorism. The latter pertains to the risk that materials within spent fuel could be used for either nuclear weapons or radiological dispersal devices. The nuclear industry, governments, and the public in countries with nuclear power programs, as well as the international community at large, continue to struggle with how best to manage spent nuclear fuel. At the heart of the issue is the fact that spent fuel contains plutonium as well as other highly radioactive fission products.

The plutonium in spent fuel raises the long-standing question of whether or not to reprocess and recycle plutonium, together with uranium, for new fuel to be burned in nuclear power reactors. The question is connected to a variety of factors: economics, energy self-sufficiency, environmental burdens of waste management, resource conservation, and nonproliferation, as well as safety. Each country's policy decisions should take into account not only domestic situations but also relevant international situations.

France, Japan, Russia, China, and India are the countries presently conducting or pursuing recycling programs alongside reprocessing. The United States, Canada, Finland, Sweden, and South Korea do not use reprocessing and recycling programs; rather, they are seeking to implement programs for direct disposal of spent fuel at a geological repository.

Whether or not reprocessing is involved, a geological final repository is necessary to dispose of highly radioactive wastes. The programs for such final repositories are always very controversial because of the tremendously high potential hazards related to the extremely high radioactivity. The programs are also increasingly complicated politically, mainly owing to domestic factors. Currently, there are two extreme cases, both in non-reprocessing countries. One is the Yucca Mountain project in the United States, which the Obama administration stated is no longer an option for waste disposal, after the United States had spent billions of dollars on the project. The other extreme case is the Swedish program.[11] In Sweden, a site was eventually selected to be one of two candidate repository sites following a decades-long, patient discussion process. The site selection is a milestone for the program, and the Swedish case suggests the great success of the country's prudent approach. The lesson to be learned from Sweden's suc-

cess is how useful social communication and acceptance by the local community can be.

Long-term safety assurances for high-level waste disposal is a central issue; intensive and extensive attention must be paid to safety based on procedural rationality that relies on social communications, as well as to safety based on substantive rationality (that is, the multiple-barrier confinement concept used in geological disposal design). Social communications are based on a step-by-step decision-making process and require non-confrontational dialogue with the public. This is exactly what Sweden has done, bringing about fruitful success in terms of selecting a site.

To obtain public understanding, one must demonstrate the safety concept based on the substantive rationality (geological disposal with multiple-barrier confinement). In Sweden, an underground research laboratory was constructed at a site where the geology is very similar to that of the real repository site. The research laboratory helped show the public the basic idea of geological disposal, and that was extremely helpful in gaining public understanding. One of the advantages in Sweden is that geology there is relatively uniform nationwide, making the technical identification of a geological environment for the actual repository relatively simple.

In Japan, the geology is extremely heterogeneous, and there is a variety of geological environments that could be candidates for a repository. Therefore, assuming that the Japanese repository site selection process will be particularly time-consuming because of both technical assessment and public involvement, Japan is pursuing a multiple-track approach, whereby the reprocessing and recycling program is under way, with interim storage as a means to manage the spent fuel. At the same time, geological disposal research has been implemented using underground research laboratories with different geological characteristics. This multiple-track approach is effective in providing flexibility for decision-making around repository site selection, but this approach also presents a disadvantage because, due to a short- and intermediate-term expedience associated with the approach, there is no sense of urgency for the government to make a decision. This lack of urgency lessens the political leadership, which is necessary for advancing the site selection process.

Japan's new Democratic Party administration, led by Prime Minister Hatoyama, issued an official statement that the nuclear policy in Japan will not change, although the new government was elected in a landslide, the result of the main campaign message, "Let us make a big change." As far as the global nuclear energy situation is concerned, however, significantly new political leadership is necessary. For instance, the new government declared that Japan aims to reduce CO_2 emissions until 2020 by 25 percent against the 1990 level, if other major countries also provide such a progressive commitment to resolve the global warming issue. If this is to be the case, Japan has to rely more on nuclear energy, which in turn requires greater public support for expanded use of nuclear energy. To obtain such public support, more visible progress is needed in the back-end of Japan's nuclear fuel cycle program – reprocessing and geological disposal – as well as better performance of reactor operations, which will not be possible without more efficient and effective regulations.

Selecting a site for a final repository will take time, and the only way to lead

a successful decision-making process is to base it on social communication that isn't confrontational, but rather is an open dialogue with the public. There are two points to be stressed. First, for nations pursuing the reprocessing and recycling option, transparency is especially required to fulfill an international commitment to nonproliferation. Nonproliferation concerns are growing, and correspondingly, the need for international communication and cooperation is indispensable for improving the robustness of each nation's program.

Second, there is a great need to have international collaboration in the area of final repository. By and large, the construction cost of final repository depends heavily on its scale, that is, the amount of highly radioactive wastes that can actually be disposed at the facility. For the new entrants to nuclear power, for instance, it does not seem to make any economic sense for each one to have its own facility. If that were the case, the cost incurred might be too high for nuclear power to be an economically attractive option in that country. Thus, international cooperation is necessary to spread nuclear power use.

Given the difficulty in selecting repository sites, as indicated from past experiences in developed nations, a special arrangement may be necessary when considering international cooperation in this area. I think that the most practical way to implement international cooperation is to establish interim storage facilities of spent fuel, and not to make a rapid attempt to build an international repository. Again, the final decision-making process must be based on open dialogue internationally.

How should the global community pursue an appropriate course of nuclear power development, beyond considerations of safety, security, and stakeholder involvement/communication? Within industry, there are new trends and activities meant to take advantage of the growth in nuclear power around the world. In terms of reactor construction business, a merger and acquisition (M&A) trend has developed in global nuclear industrial sectors. Partnerships with the Multinational Design Evaluation Program (MDEP), originally proposed by the United States and France and now under multinational discussion at the OECD/NEA, for instance, would make remarkable sense for creating an economically healthier market for countries new to developing nuclear power.

In terms of business related to the nuclear fuel cycle, more robust global partnerships seem necessary for nuclear energy to expand steadily. As far as the front-end of the nuclear fuel cycle is concerned, a number of efforts have been undertaken to assure uranium resources and their enrichment. For example, the International Atomic Energy Agency (IAEA)[12] has proposed the idea of a nuclear fuel bank. Proposals for the back-end of the fuel cycle, however, are limited, regardless of the spent fuel management program used. The key is transparency of the program, which is a prerequisite for safe and secure use of nuclear energy.

It will be critical to have multiple dimensions in new global partnerships: developed and developing nations, large and small nations, recycling and non-recycling countries, and nuclear-weapons states (NWS) and non-nuclear-weapons states (NNWS), all working together toward common goals.

As for countries with developed nuclear power systems versus countries developing nuclear power, nuclear regulatory infrastructures in developing

countries will have to be provided with appropriate aid from developed countries. In particular, comprehensive safety management needs to be established in countries developing nuclear power; the way to introduce it will depend on the social system in each country. The system should enable communication between society and the nuclear industry, and at a transitional phase, developed nations should help stimulate such communication through an international institution, like the IAEA or the OECD/NEA.

Cooperation between large and small countries is also important. The economy of each country's national fuel cycle program, for instance, depends on the total capacity of its nuclear power program. Countries with small nuclear programs may at times need special help. In particular, the technology for geological disposal of highly radioactive waste is extremely capital-intensive, and it does not make economic sense for every nation with a small nuclear program to have its own disposal program (though some propose that every nation should hold the responsibility to deal with its own nuclear waste).

A similar situation exists in the area of cooperation between countries recycling spent fuel versus non-recycling countries. Considering that reprocessing and recycling technologies are extremely capital-intensive, it makes little economic sense for every country to have its own complete recycling program, even though worldwide there is a social trend to recycle natural resources to the greatest extent possible. A particular arrangement may be required between recycling and non-recycling countries when some of the new entrants are interested in recycling.

Another dimension is the relationship between NWS and NNWS. Under the current world regime, a global architecture for peaceful use of nuclear energy could not be built without partnership between NWS and NNWS. A robust nuclear future is heavily dependent upon global public support for the peaceful use of nuclear energy. Unfortunately, concerns with nuclear power originate from the grave threats that arise from its military applications. In this respect, it is crucial for NWS to get rid of the nuclear legacy they still hold. Particularly, the highly radioactive wastes generated from defense programs should be disposed at the earliest possible time. To be specific, Russia, the United Kingdom, and the United States should take the initiative in demonstrating the technical feasibility of geological disposal, by making the disposal of their defense waste a high priority. If these countries took this step, the global opinion would be much more favorable regarding the peaceful use of nuclear power in NNWS as well as NWS.

One of the disadvantages of canceling the Yucca Mountain project is that the United States could lose the opportunity to take the initiative in demonstrating the safe implementation of a geological disposal program using its defense waste. Now it will have to postpone disposal of highly radioactive defense waste that was scheduled to be disposed of jointly with civil waste at the Yucca Mountain site. This delay could send a negative message to the world nuclear community with regard to the United States taking responsibility for its nuclear legacy and disposing of its defense waste. The Waste Isolation Pilot Plant (WIPP) in the United States, in New Mexico, specifically disposes of long-lived radioactive waste (as opposed to high-level) arising from the defense program, and is an example of a successful geological disposal program. It might make sense

to explore the possibility of using the WIPP facility to demonstrate the safe implementation of disposal of defense high-level radioactive waste, since the geological environment at the WIPP site appears scientifically suitable for high-level radioactive waste as well as long-lived waste. Though the current agreement between New Mexico and the U.S. Department of Energy (DOE) precludes the DOE, the owner of the waste, from utilizing the facility for that purpose, it would be worthwhile for the United States to rethink the agreement and show that it is taking responsibility for its defense waste.

The magnitude of nuclear power programs in developing nations should be greater than the ones in developed nations, so that the nuclear option might make a material contribution to global energy and environmental issues – in particular, global warming. In order that this might come to pass, however, safety and nonproliferation issues will need to be managed properly, and new global partnerships will inevitably and increasingly be required.

In the reactor safety area, both the defense-in-depth concept (with quality management) and improved safety communication with the public will need to be employed in every nuclear power country. While a safety system based on procedural rationality should be designed to meet the specific needs of each country, the knowledge developed thus far in developed nations should be transferred to developing countries, especially through international programs. International efforts to ensure safe nuclear operations, such as the World Association of Nuclear Operators (WANO), have been successful in improving the safety and reliability of nuclear power plant operations. WANO has played a remarkable role in providing useful information on reactor operations for member companies, and encourages new entrants in nuclear power development to become a member in order to participate in such exchanges. Japan, for its part, has been an active member in WANO and other international efforts. With its years of operations and construction experiences, Japan can provide technical and safety knowledge from both an operator's and a vendor's point of view.

Technologies connected with the back-end of the nuclear fuel cycle are tremendously capital-intensive, and it makes little economic sense for every small country to have its own program. Thus, international cooperation, entailing global partnerships, is particularly necessary. Otherwise, the steady and robust global use of nuclear power will not be possible.

Lastly, a few words on why great emphasis should be put on the need for social communication, particularly in terms of transparency. What has been proven from the past 50 years of peaceful use of nuclear energy is that transparency is prerequisite for building confidence nationally and internationally. This is true for two reasons. First, as described above, transparency plays a significant role in maintaining and improving safety performance. Second, transparency is the most effective measure for nuclear nonproliferation as well, if it is used to ensure security. In a much broader sense, transparency is tremendously effective for maintaining a safety and security culture, and thereby contributes to acceptance of nuclear energy from the public at large. Japan, the only NNWS to employ reprocessing technology, has committed to safeguards and verification at all its facilities, to provide confidence to the IAEA and international community that no diversions of nuclear

material occur. In 1999, Japan signed the Additional Protocol, providing the IAEA with a broader set of tools to search for undeclared materials and activities. Japan's collaboration with the IAEA and the international community not only has led to improvements in safeguards technology, but also illustrates how transparency of nuclear activities can enhance or improve safety and security, as well as public confidence.

Transparency is a cultural product of democracy, and conceivably, each country employing nuclear power in a safe and secure manner, through a mechanism that insists on transparency, would achieve the greatest outcome.

In a robust nuclear management system, where any country could afford to utilize nuclear power, each nation with a nuclear power program should create its own safety communication system with the highest possible level of transparency, so that it may enable all related sectors of society to participate. The current nuclear energy community should pursue this goal with highest priority.

ENDNOTES

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Mohamed I. Shaker

Nuclear power in the Arab world & the regionalization of the nuclear fuel cycle: an Egyptian perspective

The International Atomic Energy Agency's (IAEA) *Nuclear Technology Review* 2009 reported that there were 10 nuclear power plant construction starts in 2008 in China, Russia, and South Korea.[1] It seems that current expansion, as well as near-term and long-term growth prospects, remains strong in Asia. In Europe, there is mounting interest in the United Kingdom, Italy, Bulgaria, Finland, Switzerland, and Slovakia. In the United States, the Nuclear Regulatory Commission (NRC) approved 10 nuclear power uprates totaling 2,178 megawatts thermal (MWth). In Canada, two power reactor units are planned for Darlington. In 2007 and 2008, the IAEA introduced a new service providing integrated advice to countries considering the introduction of nuclear power. During that same period, the IAEA undertook 10 missions, to Belarus, Egypt, Georgia, Nigeria, the Philippines, Sudan, Thailand, and to members of the Gulf Cooperation Council (three times), to offer such advice.

The introduction of nuclear power on such a scale – dubbed by some as a nuclear renaissance – may double in the near future, raising the question of how many elements of the nuclear fuel cycle a country would be involved in. Does every country need its own nuclear fuel cycle? Or would it be more economical, with minimal risks of proliferation and an effective verification system, to include more countries in the radius of fuel cycle control? I believe those were the reasons that prompted Mohamed ElBaradei, Director General of the IAEA, to propose the creation of a multinational or regional nuclear fuel cycle in his 2003 article in *The Economist*. ElBaradei was in fact reviving previous interests in the internationalization of the nuclear fuel cycle. In his article, he identified three areas of vital importance: how to guarantee the supply of fuel for nuclear-generated electricity; how to set up one or more international repositories for spent nuclear fuel; and how to bring about multilateral oversight to sensitive parts of the front-end of the nuclear fuel cycle.

Nuclear Technology Review 2009 also reported that a number of Arab countries are interested in the introduction of nuclear power. A quick tour d'horizon of the Arab world, from east to west, reveals some facts and developments concerning nuclear technology and its affiliations in this vast area of the world, which constitutes 10.2 percent of the entire globe.[2]

Mohamed I. Shaker on the global nuclear future

Oman is interested in desalination energy options, possibly including nuclear energy. IAEA Director General ElBaradei visited the country in 2007. Kuwait, the United Arab Emirates (UAE), and Yemen had no nuclear infrastructure or regulatory authority up until recently, other than an Atomic Energy Committee or Department. The UAE, in anticipation of its investment in nuclear power, has adhered to the Additional Protocol attached to its safeguards agreement with the IAEA and has indicated its disinterest in uranium enrichment as well. The law decree (No. 6, 2009) promulgated by the UAE head of state on October 4, 2009, regulates the peaceful uses of nuclear energy within the state and adopts the basic elements included in the "Document on the General Policy of the State of the UAE in Assessing the Possibility of Developing a Peaceful Nuclear Power Program in the State," which was issued in April 2008. Accordingly, the law prohibits the development, establishment, or operation of any reprocessing or enrichment facilities within the UAE.

The Kingdom of Saudi Arabia has, since 1978, conducted several feasibility studies on utilizing nuclear power to desalinate seawater. The Saudis are world leaders in seawater desalination, but all such facilities are powered by petroleum- and gas-generated electricity. Saudi Arabia's only known previous involvement in nuclear applications is limited to experiments to produce radio isotopes using a tandetron accelerator and a cyclotron. Saudi Arabia, a party to the Nuclear Non-Proliferation Treaty (NPT), signed an IAEA safeguards agreement called the Small Quantities Protocol, which is intended for states with little or no nuclear activity and allows the kingdom to opt out of regular, intrusive inspections in exchange for a state declaration. As with Oman, ElBaradei visited Saudi Arabia to discuss the kingdom's needs. If Saudi Arabia were to invest in nuclear power, the kingdom may be asked to negotiate a new, more substantive international safeguards agreement with the IAEA.

In the Levant, Jordan is seriously interested in nuclear power and has signed a number of nuclear cooperation agreements with potential suppliers. It is also investing in exploration for uranium and in its extraction from phosphates.

Syria participated in a 2002 – 2006 IAEA study on the economic competitiveness of nuclear desalination. The Syrian elemental nuclear program includes a Chinese-supplied miniature reactor and plans for a larger research reactor to be sourced from Russia. Syria and Russia have also concluded negotiations on the construction of a nuclear power reactor coupled with a seawater desalination plant. An Israeli air raid on Syrian territory in September 2007 was allegedly motivated by the existence of nuclear equipment and/or material in a Syrian location, a possibility which is still under thorough investigation by the IAEA.

One of Lebanon's scientists had, up until recently, been the Director General of the Arab Atomic Energy Agency since 2001. Dr. Mahmoud Nasserldin is French-educated with a Ph.D. in nuclear physics from Grenoble University. As of 2009, he was succeeded by a Tunisian scientist, Dr. Abduel Maguied Magoub.

As for Iraq, we need not reiterate here the destruction and dismantlement of its nuclear apparatus before the war was launched against it in 2003, as a result of the work done by the two UN Security Council Committees, UNSCOM and UNMOVIC, in accordance with UN Security Council Resolution 687 of 1991.

Egypt has two research reactors at Inshas, northeast of the Delta. One of the reactors was acquired from Russia

in 1961, and the other, commissioned in 1997, was acquired from Argentina. Both produce radioisotopes for medical, industrial, and agricultural use. To operate these reactors, Egypt imports low-enriched uranium (LEU) from which it produces reactor fuel at its own fuel fabrication plant. Egypt also has medical facilities, accelerators, and other nuclear-related laboratories, including a hot cell laboratory.

Egypt nearly chose to construct its first nuclear power plant 20 years ago, but failed to do so in the aftermath of the Chernobyl accident in the Ukraine in 1986. After Egypt's ratification of the NPT in 1981, it negotiated a number of cooperation agreements with leading supplier states to begin the implementation of an ambitious nuclear power program. The long duration of most of these agreements makes them still valid. The great number of cooperation agreements should allow Egypt to diversify its sources in supply and types of equipment. After more than 20 years, Egypt's nuclear power project is being relaunched in the context of contributing to the energy mix in Egypt, for reasons and factors similar to those in other countries.

Egypt's decision in 1980 to invest in nuclear power came before its great discoveries of gas, which brought great relief to the energy sector and, more particularly, to the country's electricity needs. Gas was responsible for the uplift of Egyptian industries and other domestic needs – partly why Egypt did not hasten to rekindle its interest in nuclear power.

Today, Egypt relies mainly on natural gas and oil for electricity generation. In 2005 – 2006, Egypt consumed 17.3 million tons of oil and 541 billion cubic feet of natural gas. Only 12 percent of Egypt's electricity is generated by hydro power. Wind energy, currently at 230 MW capacity, generates only 1 percent of Egypt's electric power. In 2010, wind energy is expected to generate 3 percent of Egypt's total electric power. As for solar energy, Egypt is about to establish its first solar energy plant of 150 MW.

If Egypt were to invest in a nuclear power plant, with a capacity of 1,000 MW, this would save 1.78 million tons of oil, or 69.9 billion cubic feet of natural gas, per year. Over a period of 60 years, which is the average life span of new nuclear power plants, the savings in oil are expected to reach 106 million tons of oil, or 4.2 trillion cubic feet of natural gas. This would save Egypt the equivalent of 210 million tons of carbon dioxide. It is noteworthy that reserves of oil and gas are expected to be exhausted in 15 and 34 years, respectively. New discoveries in both sources of energy could extend the reserves by a few extra years. The average increase in energy demand for electricity in the last 10 years was 7 percent yearly. During 2006, the total demand for electric power was 18,160 MW, out of a total electricity-generation capacity of 21,300 MW. These figures should indicate the type of studies and comparative analyses that were undertaken to determine whether it is justifiable to add nuclear power to Egypt's energy mix. I am confident that similar studies are being carried out in other Arab countries.

The prospects for reviving the nuclear power program in Egypt are now clear. On October 29, 2007, Egyptian President Mubarak decided that Egypt would go ahead with nuclear power. Egypt will have to face up to its future electric energy needs in light of the short life span of its oil and gas resources, as well as the limitations on its hydro power (unless in cooperation with African states in the south, riparian of the River Nile, it can

double its hydro power sources). Egypt is in the process of promulgating laws regulating nuclear power, its safety and its security. A consultant, from Australia Parthons, has been chosen to assist in all phases of the program, including the preparation of tenders.

Egypt's immediate neighbor to the west, Libya, dismantled and turned over its enrichment equipment to the United States in 2004, and it has signed the Additional Protocol to its safeguards agreement with the IAEA. It has a 10 MW research reactor at Tajoura that is being converted to run on LEU (formerly it used highly enriched uranium). In March 2006, Libya signed an agreement with France to develop civilian nuclear power. French President Sarkozy and his government, which took power in 2007, have confirmed that orientation.

In Tunisia, the possibility of using nuclear as an alternative energy source to counter its limited natural gas resources has been studied since the early 1990s. At that time, Tunisia conducted a site survey and participated in an IAEA region-wide feasibility study of the use of nuclear energy for desalination in the North African states. In 2002, Tunisia undertook a more intensive nuclear desalination feasibility study with the French Atomic Energy Commission for the Skhira site in the south of the country. The study concluded that as long as gas prices remain constant, the nuclear option would not be economical for Tunisia. Yet it also concluded that in the future the country would experience electricity shortages unless new natural gas reserves were found. Tunisia has no nuclear infrastructure other than a National Center for Science and Nuclear Technology and a National Center for Radioprotection.

Tunisia is the host of the Arab Atomic Energy Agency, an Arab scientific organization and one of the Arab League subsidiary organizations with an independent identity. The Agency is concerned with peaceful uses of nuclear energy, including development and technological applications. The main role of the organization is to coordinate Arab states in peaceful applications of the atom, and to assist in research activities, manpower development, and technical and scientific information. It seeks to set up unified regulations for radiological protection and safe handling of radioactive materials, and to coordinate scientific and technical activities with concerned regional and international organizations. It supports and protects the patents in the peaceful uses of atomic energy, encourages Arab scientists in the field of nuclear sciences and technologies, and assists them in attending relevant Arab conferences.[3]

Algeria has a Chinese 15 MW heavy-water research reactor at Al Oussera; the reactor went critical in 1998. Algeria also possesses an Argentinean 1 MW research reactor that began producing isotopes in 1989, and also has a small fuel fabrication plant and rich deposits of uranium ore. Algeria is a leading candidate for nuclear power in the Arab world.

Finally, Morocco had a long-standing interest in nuclear power for seawater desalination. In the late 1990s, it carried out a feasibility study for a Chinese-built 10 MW demonstration plant at Tan-Tan, with IAEA technical assistance and financial backing from the European Union (EU). Later, Morocco studied the economics of coupling nuclear reactors with desalination systems at Agadir and Laayounne. To provide the infrastructure to help implement the program, Morocco has a nuclear research center and a radiation protection authority. In late October 2006, Morocco hosted a 12-country conference to discuss the necessary steps

to implement the Global Initiative to Combat Nuclear Terrorism, which was sponsored in July of the same year by the United States and Russia at the G8 Summit in St. Petersburg, Russia. The number of supporters of that initiative has dramatically increased since the conference.

Apart from sponsoring a number of studies, the Arab Atomic Energy Agency has generally been dormant, and its impact has not been felt in the Arab world or outside of the region. However, the 2007 Arab Summit of Riyadh was a turning point and perhaps a new lease on life for the Agency. At the Summit, the Council of the League of Arab States decided to undertake joint cooperative activities for the development of peaceful uses of nuclear energy and related technology in the Arab world, including a practical program devoted to applications in various fields, especially energy, water, medicine, agriculture, and industry. The Council requested that the Secretary-General of the League of Arab States form groups of experts and specialists, with the participation of the Arab Atomic Energy Agency, to consider ways and means for such cooperation to take place within an integrated Arab framework.

In Riyadh, attendees adopted a previous resolution inviting Arab countries to use or expand the use of nuclear technology for peaceful purposes for all fields of sustainable development, with due consideration of the diversity of their needs and of the fact that they were strictly observing provisions of all international treaties, conventions, and regulations that they have signed. Among the executive steps to be taken, the Summit provided support to the Arab Atomic Energy Agency, as the organ for joint Arab action in this field, and called upon Arab countries that have not yet joined the Agency to do so without delay, for their own benefit as well as that of joint Arab action in this field. The Summit requested that the Agency develop an Arab strategy for mastering nuclear sciences and technology for peaceful purposes by 2020.

The Riyadh Declaration Decisions struck a balance between peaceful nuclear ambitions for the Arab world and reaffirmation of the importance of clearing all weapons of mass destruction (WMD) from the region. The decisions moved away from double standards and selectiveness and warned against launching a dangerous and devastating nuclear arms race in the area. It was decided at the Summit to suspend the work of the Technical Committee, established in 1994 at the initiative of Arab countries, on the preparation of a draft treaty to establish a WMD-free, and especially nuclear-weapon-free, zone in the Middle East. The committee was suspended so that Arab policies followed during past decades could be assessed in light of current international conditions.

Over the last 13 years, the Technical Committee of the League of Arab States had been drafting a treaty to establish a WMD-free zone in the Middle East. The Arab League found no reason to make the draft text available, as it had not yet been approved by the League and as other parties outside the framework in which the draft was negotiated had not been involved or approached. The suspension of the work of the Arab League Technical Committee reflects frustration on the part of the Arab states because of the lack of implementation of the Middle East Resolution. The Resolution came out of the 1995 NPT Review and Extension Conference, sponsored by the three NPT depositary governments (the United Kingdom, the

United States, and Russia), and was put forward in conjunction with efforts to seek consensus on a decision to extend the NPT indefinitely. It also conferred on the nuclear-weapons states, as sponsors of the resolution, the responsibility to achieve universal adherence to the NPT, including by Israel and other states not party to the Treaty, and to establish the Middle East as a nuclear-weapon-free and WMD-free zone.

The clear message of the Riyadh Summit was that the Arab states would rather develop their peaceful nuclear activities in a Middle East completely free of WMD and in conformity with all the relevant international instruments they have adhered to. There would be no stability or security in the region in the presence of any nuclear-weapons capability, whether from Israel or from an Iranian potential capability. The Riyadh spirit prevailed as well at the Doha Summit, held in Qatar in March 2009, and underlined the importance of Arab cooperation and coordination in the nuclear field.

Will the Riyadh Summit be the basis for ongoing joint Arab action in the field of peaceful uses of nuclear energy? Will the success of the Summit give a boost to the Arab Atomic Energy Agency and lead to a regional or an Arab nuclear fuel cycle, fostering greater coordination and cooperation and, at the same time, ensuring regional control that could be effectively verified internationally?

Based on the tour d'horizon provided above, it is clear that Arab states would have the expertise, uranium ore deposits, research reactors, fuel fabrication skills on a small scale, accelerators, and other nuclear-related laboratories, including hot cell laboratories, necessary to develop an Arab nuclear fuel cycle. However, within the present international context and in light of policies imposed by the Nuclear Suppliers Group (NSG), Arab states, individually or collectively, would face difficulties in investing in and importing the so-called sensitive technologies: uranium enrichment and fuel reprocessing technologies. Iraq and Libya had dramatic experiences with regard to those technologies. The vehement opposition we are currently witnessing against the Iranian enrichment program is another signal that an Arab enrichment plant would not be tolerated, regardless of its location, even though enrichment is not prohibited under the NPT, and a number of non-nuclear-weapons states that are party to the NPT are investing in enrichment, including Germany, The Netherlands, Brazil, and more recently, Japan. How can the Arab states get around this dilemma in such an atmosphere? We must consider the possibilities in light of an IAEA expert group's 2005 report on multinational approaches to the nuclear fuel cycle.[4]

The regionalization of the nuclear fuel cycle raises a number of basic questions.[5]

Gradual buildup of a nuclear fuel cycle. The internationalization of the nuclear fuel cycle can only proceed in phases. Success achieved in the first phases may be an incentive to involve other stages and more actors. The IAEA, including the expert group mentioned above, tends to focus on the so-called sensitive parts of the nuclear fuel cycle – namely, uranium enrichment, reprocessing of spent fuel, and spent fuel disposal and storage. These are definitely important stages in the nuclear fuel cycle from the point of view of nonproliferation and supply, but other stages could be of great interest to a number of countries, such as uranium ore supply, fuel fabrication, and even supply of spare parts to nuclear power plants. Other stages could also

be included in a multilateral arrangement. At any rate, buildup of a regional nuclear fuel cycle in the Arab region could be expected to be slow and gradual. Restructuring the Arab Atomic Energy Agency to promote cooperation and coordination is expected to take a longer time.

The need for a supply mechanism. A supply mechanism is needed to address:

- The possible consequences of interruptions to nuclear fuel supply for political reasons; the risk of interruptions might dissuade countries from initiating or expanding nuclear power programs; and
- The vulnerabilities that create incentives for building new national enrichment and reprocessing capabilities.

A mechanism to assure the supply of nuclear fuel would be envisaged solely as a backup measure to the operation of the commercial market; states would make use of the mechanism only when supply was interrupted for political reasons. It would neither be a substitute for the existing commercial market in nuclear fuels nor would it deal with disruption of supply due to commercial, technical, or other nonpolitical reasons. If such a mechanism operated reliably, Arab countries might be relieved from looking for other alternatives (which I will say more about later). Could a renewed and bolstered Arab Atomic Energy Agency be entrusted with such a task?

The material to be assured. Existing proposals deal with supply assurance in different, complementary ways. Some proposals focus on assuring supply of natural uranium and LEU stocks, and still others focus on assurance of supply of nuclear fuel itself.[6] It has been asserted that there is also a complementary need for greater transparency in uranium markets, and that assured access to a broader range of nuclear reactor technology would be important to operators and countries seeking to reduce the risk of supply interruptions on political grounds. A number of Arab countries have made small-scale developments in fuel fabrication technologies (for example, Egypt and Algeria), and they may be more interested in assuring the supply of enriched uranium.

Modalities of assurance's mechanism. The possible modalities could include a virtual reserve of natural uranium and LEU based on binding contractual agreements for supply of such materials, plus parallel binding commitments/assurances of fuel fabrication services. A virtual reserve does not involve separate physical storage of natural uranium or LEU, but instead relies on availability from suppliers that have agreed to be part of the fuel assurance mechanism.

While an actual (physical) bank of natural uranium or LEU could be established, it was found impractical, for technical and economic reasons, to have an actual bank of nuclear fuel assemblies, given the different types of reactor designs and many variants of nuclear fuel required for them. A virtual reserve of Arab fabricated fuel would face the same problem, presupposing heavier investment in fuel fabrication by those Arab countries presently knowledgeable about this technology.

Conditions governing eligibility for benefiting from assurance mechanisms. Committing to nonproliferation would be considered a qualifying criterion. However, in accordance with the IAEA statute, an assurance mechanism would be available to all member states in a nondiscriminatory manner. For any mechanism, whether or not it involves a role for the IAEA, certain release criteria

would need to be defined and agreed upon, either by the IAEA Board of Governors or a supply consortium. Another aspect requiring further assessment is how best to ensure that the application of the release mechanism is demonstrably nonpolitical and based upon objective criteria.

If an Arab nuclear fuel cycle were to be established, it would also have to abide by IAEA standards of nondiscrimination as well as by nonproliferation criteria. An important issue here is the acceptability within the Arab world of the Additional Protocol to be attached to the safeguards agreement between the IAEA and the Arab states. Some have accepted the Protocol, including Libya and the UAE. Others have not done so yet, including Egypt. An Arab nuclear fuel cycle should aim for harmony on this matter.

Possible role(s) for the IAEA. Existing proposals envisage different roles for the IAEA, and there are still others that can be considered. The suggested roles range from IAEA administration or ownership of natural uranium or LEU stocks to administration of virtual stocks and associated parallel fuel fabrication commitments. The IAEA statute is sufficiently broad to allow the Agency to establish its own stocks of nuclear fuel purchased from, or donated by, member states for supply to another member state against charges determined by the IAEA Board; to facilitate the supply of nuclear fuel from one member state to another; and to facilitate, *inter alia*, the provision of enrichment and fuel fabrication services by one member state to another or to the IAEA. In this respect, a number of legal arrangements would be required, especially if the IAEA were to establish an actual bank of nuclear fuel.

The UN High-Level Panel on Threats, Challenges and Change, established by former UN Secretary-General Kofi Annan, produced the 2004 report *A More Secure World: Our Shared Responsibility*,[7] in which they urged that:

> Negotiations be engaged without delay and carried forward to an early conclusion on an arrangement, based on the existing provisions of Article III and IX of the IAEA Statute which would enable IAEA to act as a guarantor for the supply of fissile material to civilian nuclear users. Such an arrangement would need to put the Agency in a position to meet, through supplies it authorized, demands for nuclear fuel supply of low enriched uranium and for reprocessing of spent fuel at market rates and to provide a guarantee of uninterrupted supply of these services, as long as there was no breach of safeguards or inspection procedures at the facilities in question.

Privileging the IAEA as a guarantor of supply is due to the fact that the Agency's membership is much broader than that of the commercial consortium. Furthermore, the IAEA's track record, reputation, credibility, and relevant experience justify this reaction. However, one must take into consideration that those with permanent or semi-permanent seats on the Board of Governors are the most advanced countries in nuclear energy and also are the major supplier countries. They are also parties to the export control regimes that might not necessarily be favorable toward certain potential recipient states. In this case, the solution might be to democratize the export control regimes, especially the NSG. By offering universal admission to the regimes, suppliers and users could consult about guidelines that would be adopted for the export of nuclear equipment and material. At present, these guidelines are usually adopted without consultation with the user states. We must not assume that

seeking consultation would suffice as a remedy; a new democratic setup is badly needed.

The NSG practices and the domination of the IAEA Board by supplier countries may invite Arab countries to ponder whether their Arab Atomic Energy Agency could play the role of a guarantor of fuel supply in a regional context. Again, let us reiterate that the Agency would have to be restructured to play such a role.

The role of the nuclear industry. Consultations with the nuclear industry would be useful, particularly with the understanding that the nuclear industry would provide the required goods and services to support a supply assurance mechanism that does not have negative effects on the diversity and stability of the existing commercial market in nuclear fuels.

Other related issues. These issues pertain to how an assurance mechanism can be structured in a manner that would not result in a division – whether real or perceived – between nuclear fuel and nuclear reactor technology haves and have-nots. Also necessary is a structure that does not undermine existing multilateral, treaty-based nuclear nonproliferation norms of state sovereignty and rights. In this respect, it is important to reread Article IV of the NPT, which has encouraged parties to the Treaty to engage fully in cooperation on peaceful uses of nuclear energy. The Riyadh declaration and decisions are very much in line with the letter and spirit of Article IV of the NPT. Arab participants in a regional nuclear cycle would be equal partners sharing decisions together.

Aside from the basic questions raised by the possibility of a regional nuclear fuel cycle, there are also questions related specifically to the so-called sensitive technologies.

Uranium enrichment. In its 2005 report, the IAEA expert group noted that suppliers could provide additional supply assurances. Also, an international consortium of governments could step in to guarantee access to enrichment services, with suppliers simply being executive agents. This arrangement would be a kind of intergovernmental fuel bank.

There are also variations of the preceding option, including with the IAEA acting as the anchor of the arrangement. The IAEA would function as a kind of guarantor of supply to states in good standing, as described earlier. The IAEA might either hold title to the material supplied or, more likely, act as facilitator, with backup agreements between the Agency and supplier countries. In effect, the IAEA would establish a default mechanism only to be activated in instances when a normal supply contract had been broken down for reasons other than commercial.

As to multilateral nuclear arrangements that would take the form of a joint facility, the IAEA expert group pointed to the existence of two ready-made precedents, the Anglo-Dutch-German company Urenco and the French company EURODIF. The experience of Urenco, with its commercial-industrial management on the one hand and the governmental joint committee on the other, shows that the multinational or international concept can be made to work successfully. EURODIF has a successful multinational record as well. By enriching uranium only in France, instead of in three countries, as is the case with Urenco, EURODIF provides enriched uranium to its co-financing international partners, thus restricting all proliferation risks, diversion, clandestine parallel programs, breakout, and the spread of technology. Unlike

Urenco, EURODIF is known to have never been a manufacturer of enrichment equipment.

Is there any possibility of enlarging the two entities to accommodate more partners in the future and to make them more international than they are today in terms of financial contributions, management, or decision-making? Admitting Iran as a partner in EURODIF indicates that there was open-mindedness to the idea of accepting countries from other continents as partners. Can Arab countries benefit from this precedent, especially given that their regional nuclear fuel cycle would, in the present international context, most probably bypass enrichment, as earlier indicated? Bypassing enrichment, however, should not be construed as giving up the right to that activity, a right spelled out in the NPT.

There are national facilities for enriching uranium in other parts of the world, such as Japan and Brazil, and here, too, we can foresee that such national uranium enrichment facilities could one day be converted to multinational facilities providing services to regional neighbors and maybe beyond. By taking such steps, we would further internationalize essential parts of the nuclear fuel cycle. Also, Russian, German, American, and other offers to make enriched uranium available are of no less importance.

Reprocessing of nuclear spent fuel. The IAEA expert group noted that the present capabilities for reprocessing spent fuel from existing light water reactors and those currently under construction are sufficient for expected global demands in plutonium-recycled fuel during the coming two decades. Therefore, the expert group concluded that the objectives of supply assurances can be fulfilled to a large extent without new reprocessing facilities involving ownership. Currently, all reprocessing plants are, in essence, state-owned. An IAEA-broker arrangement could mean IAEA participation in the supervision of an international consortium for reprocessing services.

In the view of the IAEA expert group, converting a national facility to international ownership and management would involve the creation of a new international entity that would operate as a new competitor in the reprocessing market. An international entity would have the advantage of bringing together international expertise, but at the same time, it would include a nonproliferation disadvantage related to dissemination of know-how and to the return of the separated plutonium. Also, of the existing reprocessing facilities, all except two facilities (in Japan) are in nuclear-weapons states or in non-NPT states. In cases of conversion to international entities, appropriate safeguards would have to be introduced if they have not already been applied.

Because an Arab nuclear fuel cycle, in the present international context, is expected to bypass reprocessing (but without permanently giving up that right), it will have to rely on existing national facilities or converted international entities. The Arab countries may find in Japan (a heavy oil importer) a reliable partner.

The IAEA expert group believes that new joint facilities will not be needed for a long time, mainly because of the sufficient global reprocessing capacity.

Spent fuel disposal and storage. At present, there is no international mechanism for spent fuel disposal services; all undertakings are strictly national. The final disposal of spent fuel is thus a candidate for international approaches. The IAEA is encouraged to continue its effort in that direction.

Storage facilities for spent fuel are either in operation or being built in several countries. There is not yet an international market for services in this area, except for the readiness of the Russian Federation to receive Russian-supplied fuel and, possibly, other spent fuel. The storage of spent fuel is also a candidate for multilateral approaches, primarily at the regional level. Here, too, the IAEA is encouraged to continue investigation in that field.

Many political and public-acceptance issues will arise in connection with the import of nuclear materials to an existing repository. Public acceptance is already of crucial importance for setting up national repositories; it will be of even greater importance for multinational repository projects with nuclear waste and spent fuel coming from several countries.

The issue is of great sensitivity. Egypt had the experience of utterly rejecting an offer from Austria to send the waste from its aborted single reactor built outside Vienna. There was uproar in the Egyptian People's Assembly (Parliament) for even contemplating such a proposition. In light of that experience, it is highly unlikely that most Arab countries would host a multinational repository on their soil, unless they can identify a volunteer that could overcome internal difficulties or that guarantees public acceptance.

The internationalization of the nuclear fuel cycle is not a myth. As this paper indicates, internationalization in different forms can take place if political will exists, under conditions of nonproliferation and smooth cooperation. It can only be a gradual process in terms of both participants and the different stages of the nuclear fuel cycle, especially with regard to the so-called sensitive stages of the cycle: enrichment, reprocessing, and the disposal and storage of spent fuel. Most of the initiatives and proposals put forward are concerned with the supply mechanism. None has dwelt on the merits of a multinational or regional nuclear fuel cycle as suggested by the IAEA Director General. I have tried in this paper to advance a few ideas about a potential regional nuclear fuel cycle in the Arab region. The IAEA is well placed to encourage and to be involved in such an international endeavor. A first step to reduce the influence of the nuclear supplier states and their group would be to open up the group to the user states, to encourage ongoing dialogue for the benefit of both categories of states. This dialogue is missing now, and user states are often confronted with decisions made in their absence and without taking into consideration their essential needs and concerns. This new partnership should be institutionalized in a way that would guarantee new voices in the decision-making or in formulating guidelines for the export of nuclear materials and equipment.

The above situation may even lead to the formation of regional nuclear fuel cycles that would challenge the dominance of the NSG and would call into question the existence of the group in its present format. Following the Riyadh Summit, are we going to witness in the foreseeable future the emergence in the Arab region of an Arab Euratom, which could be a prelude to an Arab Union following the path that Europe has traveled since 1957?

As a first step, the Arab Atomic Energy Agency should be strengthened and restructured to play a pivotal role. The experiences of the Tlatelolco Treaty in Latin America and the Caribbean and the Argentine-Brazilian Agency for Accounting and Control of Nu-

clear Materials (ABAAC) should be instructive.

The most important element is that we must reach a stage where no supplier country alone can hamper or interrupt, for political reasons, a cooperative venture in the field of peaceful uses of nuclear energy. Our objective should be to protect the user states that have lived up to their international commitments and obligations and to allow them to continue unhindered in their peaceful nuclear activities.

Every individual state participating in an international or regional nuclear fuel cycle should feel that it has a say in the operation or the running of such an enterprise. This participatory aspect is just as important as the guarantee of supply.

Finally, and to sum up, regionalization or "Arabization" of the nuclear fuel cycle would have the following advantages:

- Economies of scale;
- Better guarantees of effective international control by the IAEA;
- Strengthened nonproliferation norms, because each party to the cycle would be checking on the others; and
- In the long run, better bridges between the developed and the less-developed countries in nuclear technology, thus maximizing equality among participants as much as possible and encouraging joint decision-making.

Closer Arab cooperation and coordination in the nuclear field could be the prelude to a sort of Arab Union. In Europe, the establishment of Euratom and the Steel and Coal Union led to the Common Market, the European Community, and, finally, the EU. We have much to learn from the European experience, which is a vivid example of how it is possible for our dreams to come true.

ENDNOTES

[1] IAEA Document Gov/2009/3, January 19, 2009.

[2] The following is based on a variety of sources, including Strategic Comments from the International Institute for Strategic Studies (IISS) (London, December 2006; http//www.iiss.org/index), with additions and comments by the author, especially with regard to Egypt.

[3] For more information, see http://www.aaea.org.tn.

[4] IAEA Document INFCIRC/1640, February 22, 2005. This part of the essay is based, after revisions and updates, on a previous article by the author entitled "The Internationalization of the Nuclear Fuel Cycle: An Arab Perspective" in the United Nations Institute for Disarmament Research's (UNIDIR) *Disarmament Forum*, issue two (2008).

[5] The following is based largely on Tariq Rauf's unpublished paper "New Framework for the Utilization of Nuclear Energy in the 21st Century: Assurances of Supply and Non-Proliferation."

[6] For existing proposals, see Yuri Yudin, "Multilateralization of the Nuclear Fuel Cycle: Assessing the Existing Proposals" (New York and Geneva, Switzerland: UNIDIR, 2009), 4.

[7] UN Document A/59/565, December 2, 2004.

Abbas Maleki

Iran's nuclear file: recommendations for the future

There have been several recent events, both domestic and international, that are likely to have an impact on the shape of a future nuclear program in Iran. First, on March 12, 2009, the five permanent members of the UN Security Council (Russia, China, France, the United Kingdom, and the United States) along with Germany (the P5+1) published a joint statement on Iran's nuclear file, reaffirming their unity of purpose and strong support for the International Atomic Energy Agency's (IAEA) essential role in establishing confidence in the exclusively peaceful nature of Iran's nuclear program.[1] The P5+1 claimed they remain firmly committed to a comprehensive diplomatic solution, including through direct dialogue, and urged Iran to take this opportunity to engage with them.[2]

Second, Iran's presidential election took place on June 12, 2009, and attracted considerable controversy. The incumbent, Mahmoud Ahmadinejad, was officially declared the winner, but the opposition candidates, Mir Hossein Mousavi, Mohsen Rezaee, and Mehdi Karroubi, at first refused to accept the results. Akbar Hashemi Rafsanjani, a veteran of the Islamic Revolution and head of the powerful Assembly of Experts, did not send his congratulations to Ahmadinejad. Widespread demonstrations occurred in Iran after the election. Few observers expressed the view that, because Iran's foreign policy is connected to Supreme Leader Ayatollah Ali Khamenei, there would be no change in Iran's nuclear policies and activities, regardless of the president. Nevertheless, it seems the situation for Iran's policies has changed after the election because of new internal and external pressures.

Third, on July 11, 2009, Iran's Foreign Minister, Manouchehr Mottaki, said Iran is preparing a new package of political, security, and international issues to be put to the West. And on July 17, 2009, President Ahmadinejad named Iran's former envoy to the IAEA, Ali Akbar Salehi, the new vice president and head of the Atomic Energy Organization of Iran (AEOI).[3] Salehi replaces Gholam Reza Aqazadeh, who resigned after holding the post for 12 years. Salehi served as Iran's ambassador to the IAEA from 1997 to 2005.

These recent developments call for rethinking the direction for Iran's nuclear activities. The Iranian election has made the job ahead much harder, but the determination to find ways to

build trust and to create a strong diplomatic process has never been greater.

Nuclear energy has two facets. When used for peaceful purposes, such as power generation, medical services, agriculture, and industry, it can contribute to improvements in quality of life. However, it can also be used for military or criminal purposes. Thus, there are both great opportunities and great risks. Two of the greatest opportunities arise from the contributions nuclear power can make to energy security and environmental challenges.

Energy Security. Nuclear energy can ease concerns about security of energy supply. As economies grow, energy demands also increase. In regions such as Asia and the Middle East, plans for and expressions of interest in nuclear energy have been increasing. The expectation that nuclear energy will fill the gap between energy demand and supply has become very high.

An objective review of the facts makes clear Iran's need for alternative sources of energy, including nuclear. According to a study by the U.S. National Academy of Sciences, "Iran's energy demand growth has exceeded its supply growth," and therefore, "Iran's oil export will decline," or even "could go to zero within 12 – 19 years."[4] The study acknowledges that Iran's need for nuclear power is "genuine, because Iran relies on money proceeds from oil exports for most revenues, and could become politically vulnerable if exports decline." Nuclear reactors, the report adds, "will substitute for the power now generated by petroleum, thus, freeing petroleum for export." In fact, Iran's current plans to produce 20,000 megawatts (MW) of nuclear electricity by 2020 may save Iran 190 million barrels of crude oil every year, or nearly $14 billion annually.[5]

Environmental Challenges. Nuclear energy is also expected to contribute to global and national efforts to cope with global warming, as carbon dioxide emissions from nuclear are much smaller than those from fossil fuel sources. Compared with major energy sources, including other non-fossil-fuel alternatives, nuclear power is one of the most effective energy sources to reduce CO_2 emissions.[6]

Aside from the expected contributions to energy security and environmental challenges, a rationale for promoting nuclear energy in Iran must take into account economics, energy and technical independence, and military policy/national security.

1. Iran's civil nuclear program has a clear economic rationale because Iran has a need to generate revenues from the sale of fossil fuels.

2. Iran's insistence on controlling its own enrichment process is the logical consequence of its diversification and energy security policy, in addition to its aim to establish technical independence. This goal is itself fully within the limits of the Nuclear Non-Proliferation Treaty (NPT).

3. As made clear in assessments by the U.S. intelligence services and joint U.S.-Russia track-2 assessments,[7] Iran's decision to pursue a military nuclear program is ambiguous. A decision on whether Iran will produce highly enriched uranium (HEU) has not yet been taken, and there is still no decision about forging ahead with a nuclear program. The missile program is on a different level compared to the nuclear program. The report concluded that there is at present no intermediate-range ballistic missile (IRBM) or intercontinental ballistic

> missile (ICBM) threat from Iran, and that such a threat, even if it were to emerge, is not imminent.[8]

The rationale for promoting nuclear energy is based on Iran's understanding of questions of rights and questions of security. Iran believes that each nation has the "inalienable right" to enjoy the benefits of the peaceful use of nuclear energy, in conformity with the provisions of nonproliferation and safeguards obligations in the NPT and the IAEA statute. Many international commentators believe that this inalienable right should not permit the acquisition of sensitive nuclear materials and technology without transparent and plausible plans for strictly peaceful programs. As a result, Iran's government and people have come to believe that they are being denied the right to access peaceful nuclear technology despite Iran's expression of readiness to guarantee the "three Ss": safety of its facilities and operation; security of facilities and materials; and safeguards.

While Iran expects nuclear energy to play an increasing role in bettering Iranian lives, nuclear energy also poses serious security challenges to Iran's national interests. This is especially true in light of rising nuclear proliferation threats caused by the diversion of peaceful nuclear programs to military use, by withdrawal from international nonproliferation treaties and agreements, and by theft or illicit trade of nuclear materials by non-state actors. Some of Iran's neighbors – Pakistan, Afghanistan, and Iraq, and the Caspian Sea and Persian Gulf regions in general – pose particular risks in terms of nuclear proliferation.

Iranian leadership rejects double standards on nuclear violence. They feel that insisting that Iran heed UN Security Council resolutions for nuclear programs is hypocritical when Israel's nuclear weapons capabilities do not face the same mandate. "There are a number of resolutions" from the IAEA and other organizations "calling on Israel to join the NPT, calling on Israel to place all their nuclear facilities under inspection of the IAEA, and obviously by getting rid of their nuclear weapons, as allegedly they are," says Gustavo Zlauvinen, representative of the IAEA Director General to the UN.[9] Akbar Etemaad, the first head of the AEOI during the Shah's era, says:

> The U.S. and its allies fear that even building a peaceful enrichment capability would allow Iran to covertly produce weapons-grade material, and have argued that Tehran's violations of transparency and disclosure requirements of the NPT should mean it has forfeited its right to enrich uranium. But that argument has so far not been embraced by the U.N. or the IAEA, which reports there is no evidence that Iran was working actively to build nuclear weapons.[10]

Indeed, based on Islamic jurisprudence, the development and use of weapons with indiscriminate impact on the population and the environment are prohibited. The leader of the Islamic Republic has issued a religious decree against weapons of mass destruction (WMDs) and specifically against the development, production, stockpiling, and use of nuclear weapons.[11] From a strategic point of view, Iranian leaders realize that nuclear weapons do not provide domestic stability or external security. Iran's policymakers believe that development or possession of nuclear weapons undermine Iranian security. Even the perception that Iran is pursuing nuclear weapons negatively impacts Iran's power by decreasing its regional influence and increasing its global vulnerabilities.

Iran does not need nuclear weapons to protect its regional interests in the immediate neighborhood. In fact, to augment Iranian influence in the region, it has been necessary for Iran to win the confidence of its neighbors, an effort that will inevitably suffer from such perceptions. Furthermore, with the current state of its technological development and military capability, Iran cannot reasonably rely on nuclear deterrence against its adversaries in the international arena or in the wider region. Engaging in a spiraling arms race to establish and maintain nuclear deterrence would also be prohibitively expensive, draining the limited economic resources of the country.[12]

New multinational mechanisms to assure supplies of nuclear fuel, at market prices, to countries with peaceful nuclear energy programs should be given a key role in nuclear power development. These mechanisms not only assure fuel supply, but also promote nonproliferation and the sharing of nuclear energy opportunities on a multilateral basis.[13] The West Asia region, including the Persian Gulf, would particularly benefit from exploring the feasibility of an International Nuclear Consortium (INC) for multilateral nuclear enrichment and management of spent fuel, under the supervision of the IAEA and with several operators. There are two options for Iran's participation in such a consortium:

1. Designing a consortium with the joint participation of the AEOI and European companies; or
2. Establishing a regional organization that would lead to the creation of a consortium in the West Asia region, called the West Asia Atomic Energy Agency (WAAEA). The WAAEA would set up a regional fuel cycle. (It remains to be determined politically if this INC can include Iran or if it would be parallel to another international fuel cycle under strict IAEA surveillance.)

The most difficult question is whether multinational enrichment facilities should be encouraged in potentially unstable areas in return for rolling back incipient nuclear weapons programs. In 2005, using the model suggested by IAEA experts, Iran proposed to convert its enrichment facilities to regional or multinational schemes, which provide the greatest degree of transparency by allowing the concerned parties to participate in the ownership and operation of these facilities. However, none of these proposals, which were presented by Iran from January 2005 to October 2006, received any meaningful consideration, primarily due to the tendency of the United States to manufacture a nuclear crisis instead of searching for a solution. It is worth noting that Iran's proposal for the establishment of an international consortium was initially considered very promising by the EU High Representative for Common Foreign and Security Policy Javier Solana, leading to public statements of progress following his meetings with Iran's nuclear negotiator. In a letter dated May 8, 2008, to the UN Secretary-General from the Foreign Minister of Iran, the Iranian government stated that it is ready to consider "establishing enrichment and nuclear fuel production consortiums in different parts of the world – including in Iran." The letter also spoke of nuclear disarmament.

In 2007, a study by John Thomson and Geoffrey Forden of MIT suggested that measures can be taken to prevent the expropriation of a multinational facility by the Iranian government, and that the likelihood of discovering any concealed enrichment facility in Iran

would be enhanced by establishing a multinational facility. They proposed a multinationally owned and operated enrichment facility located in Iran, using Urenco or Russian centrifuges, that would supplant Iran's nationally operated enrichment facility. (A requirement for international staffing should be a part of the agreement in places like Iran, where regional security considerations are a factor.) Their analysis describes legal, organizational, and technological barriers to nuclear proliferation, as well as barriers to nationalization.[14] In the model they outline, consumer countries would be heavily involved in ownership and management.[15] Forden and Thomson reported that Iranians they spoke with expressed an interest in involving India and South Africa in such a facility.

Experts at MIT have proposed another approach that could resolve the impasse (if tailored to meet the bottom lines of all sides).[16] A joint-venture enrichment plant could be established in Iran (meeting the Iranian desire for enrichment on their soil), but with an international staff on duty around the clock and with the use of efficient European centrifuges enclosed in "black boxes" (meeting the Western demand that the approach not give Iran a leg up in centrifuge technology, which could be applied to military use). Iran would own the plant jointly with European countries (possibly with Russia and China as well), making any attempt to shift the facility to weapons work a seizure of other nations' property. The countries would manage the facility jointly under continuous and intensive international inspection. The black box arrangement is the same one planned to protect proprietary European centrifuge technology at a new nuclear plant in the United States. This arrangement would be coupled with a no-attack commitment, political dialogue, verification steps, and a halt to Iran's own enrichment work.

Reliable assurance of fuel supply is key to effective multilateral mechanisms. Assurance of supply for non-nuclear-fuel-cycle states (in other words, putting the multilateral approach to the nuclear fuel cycle in practice) would be significant in shaping and embedding robust nonproliferation norms and habits in the international community.

Further research on international involvement in Iranian nuclear facilities has been done at Harvard's Belfer Center for Science and International Affairs. Associate Professor of Public Policy and Co-Principal Investigator of the Project on Managing the Atom Matthew Bunn has expressed his views on potential contributions of international staff or ownership of key facilities in Iran. He suggests an international staff on duty around the clock, but one that would work with Iranians. He believes that having zero centrifuges in Iran would be the best outcome for U.S. and international security, but that insisting on zero centrifuges is likely to lead to no agreement.[17]

In late 2006, President Ahmadinejad said that in five years (that is, by 2012) Iran would begin to produce nuclear fuel and sell it to Western countries at a 50 percent discount. The offer was made contingent on the West ceasing its programs to reprocess spent nuclear fuel. Iran's initiative was reinforced by the first test run of the second centrifuge cascade (164 P-1 centrifuges) at the Natanz isotope separation facility. The productivity of one Iranian centrifuge is about three separative work units (SWU); the buildings at the Natanz factory can hold up to 54,000 centrifuges of Iranian production, with a total capacity of about

150,000 to 160,000 SWU of uranium hexafluoride for the production of civilian nuclear fuel. At the current price of about $160 per SWU, the sale of all fuel produced at the Natanz factory in a year (given a capacity of 150,000 SWU), even with a 50 percent discount, would bring in $12 million per year.[18] This is an insignificant sum for oil-exporting Iran, but a successful contract would allow Iran to take the first step toward establishing itself as a provider of nuclear fuel cycle services on the world market.

At around the same time that Iran announced this initiative, Tehran was offered the opportunity to host a Urenco enrichment facility on its territory. The facility would produce materials for an international fuel bank controlled by the IAEA. As Forden and Thomson proposed, the facility could be controlled jointly by the IAEA and the investor (the European Troika and Urenco). Moreover, their proposal did not exclude the option of using the Iranian P-1 centrifuge and replacing it in the future with new Urenco models (TC-12 or even the TC-21).[19] According to the Forden and Thomson proposal, the factory could house 3,000 TC-12 centrifuges, which would correspond to the production volume of 120,000 SWU, worth $56 to $84 million. At the same time, the production of 5 million SWU per year would require the installation of 125,000 centrifuges, while the expenses on the construction of the enterprise would reach $2.3 to $2.4 billion. The installation of 50,000 TC-21 centrifuges would allow the production of about 840 tons of enriched uranium per year (at 4 percent enrichment), which would be enough to load 40 standard 1,000 MW reactors, fully covering Iran's potential needs for enriched uranium and still allowing for exports. However, this initiative was not embraced by Urenco and was not pursued any further.[20]

Iran's nuclear file has pivotal impacts on Iran's relations with other countries. Bilateral, multilateral, regional, and international ties between Iran's government and other players have been affected tremendously by Iran's stance on nuclear technology. Iran's Foreign Minister, Manouchehr Mottaki, must manage the future of Iran's international relations following the post-election chaos of June 2009.

Iran's relations with the P5+1 have been mixed. After October 2003, Iran continued some of its enrichment-related activities, but Tehran and EU3 (Germany, France, and Britain) agreed in November 2004 to a more detailed suspension agreement. Iran resumed uranium conversion in August 2005 under the leadership of President Ahmadinejad, who had been elected two months earlier. In January 2006, Iran announced that it would resume research and development on its centrifuges at Natanz. In response, the IAEA Board adopted a resolution on February 4, 2006, that referred the matter to the UN Security Council. Two days later, Tehran announced that it would stop implementing the IAEA's Additional Protocol, which provides for broader IAEA inspections. In June 2006, the P5+1 presented a proposal to Iran that offered a variety of incentives for Tehran. The proposal called on the government to "address the [IAEA's] outstanding concerns . . . through full cooperation" with the Agency's ongoing investigation of Tehran's nuclear programs; to "suspend all enrichment-related and reprocessing activities"; and to resume implementing its Additional Protocol.[21] These requirements have also been included in several UN Security Council resolutions, the most recent of which, Resolution 1803, was adopted March 3, 2008. That resolution called on IAEA Director General ElBaradei to report within 90 days on

whether Iran had complied with the Security Council requirements, adding that the council would respond to Iranian noncompliance with additional sanctions. ElBaradei's May 26, 2008, report to the Security Council and the IAEA Board indicated that Tehran has continued to defy the council's demands by continuing work on its uranium enrichment program and heavy-water reactor program. Iranian officials have repeatedly stated that Iran will not suspend its enrichment program.

EU High Representative for Common Foreign and Security Policy Javier Solana traveled to Tehran on June 13, 2009, to present a revised version of the June 2006 offer, on which the P5+1 had reached agreement in early May. Tehran has told the IAEA that it would implement its Additional Protocol "if the nuclear file is returned from the Security Council" to the Agency. It is, however, unclear how the council could meet this condition. Even before the confirmation of a new term for President Ahmadinejad, it was always likely that Iran's response to the months-old invitations to talk from both President Obama and the six negotiating countries would be wary and tough. Still, the Iranians are likely to return to the negotiating table at some point; when they do so will depend on how soon the turmoil within the political establishment dies down. Given skepticism in the West about Iran's election results, fresh Iranian government resentments will now be on the table alongside old ones. Crucially, though, these grievances are unlikely to sink the talks before they get started: the issues are too important. Neither side, for that matter, has a better policy in mind.

Political relations between Europe and Iran are strained because their interests often clash, they do not trust each other, and they run their domestic affairs very differently, as Richard Dalton, former British Ambassador to Tehran, has said.[22] Perceptions matter. In the last year, Iran's rulers have interpreted sympathetic Western media reports of demonstrations, especially post-election, as interference arising from hostility. Continued multilateral talks and diplomacy are needed to de-escalate the crisis over Iran's nuclear program, and Europe should be heavily involved in this process, even if it is long and difficult.

Relations (or lack thereof) between the United States and Iran following the Islamic Revolution were often not warm, but since 1996 the relationship has worsened because of Iran's intention to invest seriously in nuclear technology. Iran was worried by the United States' post-9/11 wars in Iraq and Afghanistan, which serve to encircle Iran; its categorization of Iran as part of an "axis of evil"; and its branding of Iran as a new Cold War enemy, as recommended during the Bush administration, thus precluding the politics of engagement. In 2004, the United States changed its nonproliferation threshold from objecting to any nuclear facility in Iran to objecting to enrichment activities. Many commentators in Iran believe that a solution to the nuclear standoff will come from reestablishing relations between Washington and Tehran.[23]

I think Iran's economic, political, and social problems are rooted in cultural and historical trends that will not be resolved overnight by resuming relations. Hard-liners in Iran feel that America's power is in decline and that Tehran should take advantage at this juncture. However, they leave two questions unanswered: first, will American power diminish before it can damage Iran? Second, will the end of American

dominance coincide with the appearance of a new unipolar power or with the creation of a multipolar world system? If the latter, will Iran be prepared for a multipolar environment?

Iran's relationship with Russia has been somewhat more productive. Russia has proposed a Russian-Iranian joint venture whereby fuel for Iran's reactors would be enriched in Russia rather than in Iran. The venture would use Russian centrifuges, and Iranian scientists would not have access to them. Iran already has experience with delays in Russian nuclear supplies, and insisted on continuing its own centrifuge development, which the United States and some European countries reject. Russia's proposal could serve the interests of all sides, if coupled with several additional steps. First, all sides should agree on three steps to guarantee that fuel to Iran's reactors will not be cut off: (1) the major nuclear fuel suppliers should form a commercial consortium that would guarantee to step in if Russian supply were interrupted; (2) the United States, Russia, and other countries should contribute enriched uranium to an IAEA-controlled fuel bank, whose rules would require it to provide fuel if there were an interruption of supply unless it was ordered not to do so by the Security Council; and (3) Iran and the major powers should establish a stockpile of some three years' worth of nuclear fuel to be held in Iran (much like the U.S. strategic petroleum reserve).

There is hope for Iran's future successful engagement with these international partners and for Iran's plans to pursue a robust nuclear power program. I offer these final recommendations, in international, domestic, diplomatic, multilateral mechanisms, and technical areas, to suggest ways forward as Iran seeks to strengthen and expand its nuclear file.

International Issues. An ambitious reinvigoration of the grand bargain that was struck 40 years ago in the NPT is needed to usher in a new era of cooperation on preventing proliferation. The renewed grand bargain will need to combine steps that can be taken immediately alongside a vision for the longer term. It will also need to draw in states that are not parties to the NPT. Rather than rushing toward confrontation, with all its risks, all sides must put historic antipathies aside and find face-saving solutions. To give the Iranian advocates of compromise a chance to succeed, the United States and the other major powers need to put offers on the table that will show the people of Iran that nuclear restraint and compliance will put their nation on a path toward peace and prosperity.

Article VI of the NPT legally obligates the nuclear-weapons states-parties to negotiate in good faith toward nuclear disarmament. At the 2000 NPT Review Conference, those states agreed that the Treaty represented an "unequivocal undertaking" to "accomplish the total elimination of their nuclear arsenals."[24] This commitment is an integral part of the NPT bargain, and the need for the NPT to become universal cannot be stressed enough. Nuclear-weapons states must recommit to the vision of a world free of nuclear weapons and take firmer steps in that direction. Iran does support a path toward a world free of nuclear weapons.

Any viable solution needs to meet the bottom lines of all sides. For Iran, this means reliable civilian nuclear energy, defense of its rights under the NPT, maintenance of its pride and technological development, and assurances against attack. For the United States and Europe, the bottom lines are no nuclear weapons in Iran; a broad and

verifiable gap between the nuclear activities that would continue in Iran and a nuclear weapons capability; and full Iranian cooperation with verification (including resolving all questions about past nuclear activities). The West's longstanding complaint about Iran's other policies, and Iran's complaints about the West, must be addressed; however, it is unlikely that all of these problems can be solved in an initial nuclear deal.

All participants (including the United States) should assure Iran that they will not attack or threaten to overthrow Iran's government as long as Iran complies with the nuclear deal and does not commit or sponsor aggression. Such a pledge is key to changing Iranian perceptions that Iran should retain a nuclear weapons option. Iran has already offered to sign mutual non-aggression pacts with its neighbors.

Domestic Issues. Iranians have no desire for international isolation, and the government of Iran is part of, and must be responsive to, Iranian society. The general public does not consider the nuclear issue to be of vital importance. Nuclear technology will do little for the average Iranian. It cannot create more jobs for a country that needs 1 million jobs annually; it cannot change the chronic low efficiency, productivity, and effectiveness of the economy and management; and it will do nothing to improve Iran's commercial ties with the rest of the world. Much of Iran's political elite does not seem ready to engage in a risky undertaking that might jeopardize the very existence of the Islamic government. Iran has a track record of rational action over the past 30 years in a turbulent region.

The result of the presidential election in June 2009 and its consequences have changed Iran's government position, and President Ahmadinejad may likely be forced to take a new approach, especially regarding the nuclear file. In addition, the June election was not so much a barometer of support for or against President Ahmadinejad as it was a stage in the overhaul of the political system in its entirety. The appointment of Ali Akbar Salehi as head of the AEOI also shows positive progress toward a compromise between Iran and international organizations such as the IAEA. The choice of Iranian representative in the next round of talks will be very important; many recommendations have surfaced for Iran to send Salehi instead of Saeed Jalili, Secretary of the Supreme Council on National Security.

There is a lively debate among Iranian intellectuals on these very questions. Emerging from the debate is the suggestion that the government of the Islamic Republic of Iran, which has survived 30 years without ties with a superpower and which has withstood various sanctions, would be more stable should it decide to pursue a rapprochement. It is hoped that in the next round of talks Iran will agree that while it has every right to enrichment, it will not exercise this right for the time being, or will do so by way of a multilateral mechanism. This approach would not require Iran to disavow any of its NPT rights to peaceful nuclear pursuits. Indeed, Iran would ratify the Additional Protocol, and it would actively cooperate to clear up lingering questions from the IAEA, including voluntarily taking steps beyond the Additional Protocol. This cooperation would also allow Iranian scientists participation in international development of cutting-edge nuclear and non-nuclear energy technologies that pose little security risk.

Diplomatic Issues. Iran must take into account the possible end of diplomatic isolation by the United States. Despite

the important role of European players, Iran's security concerns and its regional role in the Persian Gulf, the Middle East, the Caspian Sea region, and West Asia could be considered by the United States, owing to its political and military presence in the region. The fate of the U.S. administration is related to the development of affairs in Iraq, the Middle East, Afghanistan, and with energy geopolitics in general. In all of these fields, Iran is a player. Without significant engagement between the United States and Iran on several areas of shared interest – Iraq, the Taliban and Afghanistan, drug trafficking, and al Qaeda – the starting point for ultimately comprehensive negotiations would be all but impossible. Direct dialogue between the United States and Iran on security in Iraq, Afghanistan, and the Persian Gulf, as well as Iran's ability to play an even more constructive role in regional stability, would set the stage for a thaw in U.S.-Iran relations.

The P5+1 would continue to be the main vehicle for the international community, and would serve as the most likely avenue to end the nuclear dispute with Iran by diplomatic solution. Gradual engagement with Iran is the most reasonable process, beginning with EU Foreign Policy Chief Solana and then adding the United States and other P5+1 countries to the talks. It is also important that Ahmadinejad see these talks as garnering international recognition and attention for Iran.

The other recommendation for upgrading coordination and also for monitoring Iran's nuclear activities would come from companies and corporations that work with all sectors of nuclear development. Iran is trying to normalize its nuclear file, and one part of this process involves interaction between Iranian nuclear companies and their counterparts in other countries.

Sanctions are another area that requires further diplomatic attention. Sanctions of products and goods, such as petrol, are likely to hurt ordinary Iranians more than government. U.S. threats are not seen as being directed against Iran's government but against Iranians in general.

Multilateral Mechanisms. Should Iran achieve its stated goals, it could become a sort of West Asian Japan – that is, a state without nuclear weapons but possessing virtually all stages of the nuclear fuel cycle. It should be noted that Japan, in spite of its incomparable scientific and technological capabilities, was never able to develop and manufacture a reliable centrifuge. The result has been a gap between Japan's installed capacity of 1 million SWU and its actual production of about 300,000 SWU. Starting in 2010, Japan plans to reequip its enrichment facilities with a new type of centrifuge.

Multilateral mechanisms should not create new nuclear haves and have-nots. International interdependence is already a fact in the area of nuclear fuel supply, and it will be increasingly important, as most "national" fuel cycle programs have international elements. Therefore, for some countries, especially those with small-scale nuclear programs like Iran, it would be more efficient to rely on an international mechanism as a backup to fuel procurement through market mechanisms. Multilateral approaches may provide an alternative measure for states to procure nuclear fuels. Furthermore, international interdependence would help ensure that "national" programs would not divert into military purposes, as interdependence could function as a mutual oversight mechanism.

The Iranian initiative to sell fuel can be used as a means of exercising indirect

control over the Iranian nuclear program as a whole. Should a political decision to purchase Iranian fuel be made, for example, by European companies, the Iranian nuclear program could move from the political to the commercial level. A contract with a Western energy company would inevitably include obligations for Iran to allow IAEA control over the capacities of its factory.

Technical Issues. Iran feels the need to invest more in the human resources necessary for high-tech industries, especially the nuclear sciences. The international community should provide necessary assistance (both technically and financially) to help Iran meet this need as well as to share best practice in safety, security, and nonproliferation activities. The international community should also cooperate with Iran in establishing a regulatory framework and administrative capacities to properly address safety and liability.

Finally, nuclear energy would be an effective means to contain the increase of CO_2 emissions. Relevant mechanisms therefore should be available for nuclear energy projects. The creation of a policy mechanism to incorporate systematically the promotion of nuclear energy in efforts to tackle global warming and to reduce air pollution in Iran (where the consumption per capita of exhaustible energies is two-and-a-half times more than the world average) would be attractive.

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Anatoly S. Diyakov

The nuclear "renaissance" & preventing the spread of enrichment & reprocessing technologies: a Russian view

Concerns about sharp growth in oil and natural gas prices and shortages of fossil fuel reserves have led many countries, including developing countries, to express interest in nuclear power. An additional factor contributing to the growth of interest in nuclear power is essential improvements in reactor technology. Since the Chernobyl disaster in 1986, for example, the reliability and efficiency of nuclear power plants (NPPs) have grown substantially.

Russia is among the countries that are pursuing very ambitious programs of nuclear power development. Russia has 31 commercial power reactors at 10 sites, with a total generating capacity of about 23 to 24 GWe,[1] which provided about 16 to 17 percent of Russia's electric power in 2008. The operating NPPs include six VVER-440 reactors, nine VVER-1000 reactors, eleven RBMK reactors, four EGP-6 models, and one BN-600 fast breeder reactor. The total energy output of Russia's units was improved during recent years, and the capacity factor of its reactors increased from 56 percent in 1998 to 77.7 percent in 2007.

In 2006, the Russian government outlined a long-term Program for the Development of Russia's Nuclear Sector. The program's main goal is to respond to growing annual energy demand and diminish the share of domestic gas and oil consumption for electricity production. Reductions in domestic gas consumption could give Russia's state corporation Gasprom the opportunity to export more gas to the West and thereby to earn more profit. Some of the new nuclear power units are designed to power Gasprom's commercial enterprises, such as the NPP at Kola Peninsula as well as floating NPPs, which will be used for the development of new gas deposits under the Arctic Circle. In addition, because much of Russia's electrical generating capacity is coming to the end of its life, this program is also aimed at the replacement of existing generating infrastructure, including replacement of Russia's aging nuclear generating capacity. The program calls for nuclear energy to provide 25 percent of Russia's electricity production by 2030 and for the construction of 42 new nuclear reactors.

In April 2007, President Vladimir Putin signed a decree consolidating Russia's civilian nuclear activities within one giant state-owned corporation, Rosatom. It incorporates uranium mining, enrichment, nuclear fuel fabrication, operation of NPPs, manufacture

of large nuclear-related equipment, construction of NPPs at home and abroad, and nuclear-energy R&D institutes and universities. One of its missions is to compete in the global nuclear market with other industry giants such as France's AREVA. Rosatom will also try to attract investments to help expand Russia's domestic nuclear power production capacity.

Rosatom has begun implementing a long-term development plan for the design of advanced nuclear power systems, the construction of advanced light water reactors, and the next generation fast breeder reactors. The overall plan is comprised of specific plans to increase uranium mining, advance fuel development, and expand enrichment services, manufacturing, and construction capabilities both domestically and within international partnerships. On September 20, 2008, the Russian government approved a new program that covers Rosatom Corporation activity through the 2009 – 2015 period. The total cost of the program is 2.084 trillion rubles (approximately U.S. $83 billion), of which 1.264 trillion rubles (approximately $50.5 billion) will be provided by Rosatom and 820 billion rubles (approximately $32.8 billion) from the federal budget.[2]

Seven nuclear units are under construction currently in Russia, four of them projected to begin operation between 2009 and 2012.[3] According to the program approved on September 20, 2008, construction of two new VVER-1200 units is to be initiated each year, starting in 2009. By the end of 2015, 11 new nuclear power units are to be put into operation[4] and construction is to be initiated on an additional 10.[5] Shortages of qualified workers and rising costs of nuclear construction could delay the realization of these plans, however.

Rosatom is also pursuing a very aggressive program of nuclear power construction abroad. Currently it is building two VVER-1000 light water reactors at the Koodankulam NPP in India, and one at the Bushehr NPP in Iran. Rosatom has won a tender on construction of two nuclear power units at the Belene NPP in Bulgaria. On December 5, 2008, Russia signed a contract with India to construct four more units at the Koodankulam NPP. According to Vladislav Karagodin, deputy director of Atomenergoprom, Rosatom expects to construct 12 power plants overseas by 2020. Atomstroyexport, a Rosatom division responsible for construction of civil nuclear facilities abroad, is a leading contender to build four power plants at the first NPP in Turkey, as well as two power plants in Belarus and Armenia. Just recently, Atomstroyexport signed a contract with China Nuclear Energy Industry Corporation (CNEIC) for constructing two fast neutron reactors BN-800 in China. It is expected that construction on the first of them will begin in August 2011. Also, Rosatom is actively negotiating with Algeria, Argentina, Brazil, Chile, Egypt, Libya, Malaysia, Mongolia, Morocco, Namibia, South Africa, and Vietnam on the construction of NPPs.

Beyond 2015, the expansion program is more uncertain, chiefly because Rosatom is expected to find its own funding by that time. However, by converting to a corporation, Rosatom can now retain its profits from selling power, building NPPs abroad, selling nuclear fuel, and selling uranium enrichment, as well as by attracting investments from other Russian corporations, like Gasprom, for building domestic NPPs. Continued government construction subsidies may also be available – if not from the federal government, then perhaps from the regional governments.

Russia's financial system and economy have not been immune to the current global financial and economic crisis, which has reduced its financial reserves. As a result, the crisis has made full realization of Russia's plans for nuclear power development highly uncertain. Rosatom chief Sergei Kiriyenko has admitted that Russia's economic recession will force an amendment of the country's construction schedule for new nuclear reactors because of a drop in domestic electricity consumption.[6] At the same time, Prime Minister Vladimir Putin has declared that Russia's plans on nuclear power should not change, and Russia should put in operation 26 new nuclear power units by 2020.[7] Nevertheless, some Russian experts believe that Rosatom will take economic changes into account and might amend plans for NPP construction.

The global economic crisis will affect the plans of countries that have announced an interest in nuclear energy, adding uncertainty about whether many of them will follow through with their plans. However, much of the growth in nuclear power has been in Asia, and this tendency is unlikely to change with the economic crisis. The plans of China, India, and Russia to develop nuclear power could maintain the global interest in acquiring nuclear energy. And it is reasonable to expect that some countries that were less impacted by the economic crisis, particularly countries in the Persian Gulf region that possess huge financial resources, will follow through on their plans. This could result in nuclear power spreading to an additional dozen countries.

The anticipated growth of nuclear power around the world may lead to the spread of nuclear fuel cycle technologies as well. The expectations associated with a renewed *interest* in nuclear power and the *rate* of nuclear power growth in the world may be exaggerated; at the very least we can expect that the growth would occur not immediately, but over a long period. Nevertheless, there are definite concerns about the implications of nuclear power expansion for the nuclear nonproliferation regime. Driving these concerns is a sense that, beyond interest in nuclear power, developing countries also have an interest in retaining their right under the Nuclear Non-Proliferation Treaty (NPT) to possess nuclear fuel cycle technologies. A potential spread of nuclear fuel cycle technologies, especially technologies for uranium enrichment and for reprocessing spent fuel to separate plutonium, poses a serious concern to the nuclear nonproliferation regime because enrichment and reprocessing capabilities give states the capability to produce fissile materials for weapons.

This is not a new problem. Indeed, as early as 1946, the Acheson-Lillenthal report declared that proliferation risks are inherent to the nuclear fuel cycle. If nations engage in fuel cycle activities it increases the risk of:

- Spread of sensitive technologies from declared facilities, resulting in their illegal transfer to other entities;
- Diversion of nuclear materials from declared fuel cycle facilities;
- Running a military program at undeclared fuel cycle facilities; and
- Breakout – that is, withdrawal from the NPT and the subsequent use of safeguarded nuclear facilities for military purposes.

The reality of these dangers was recently demonstrated by North Korea and the A.Q. Khan network. International Atom-

ic Energy Agency (IAEA) Director General Mohamed ElBaradei has said that the fuel cycle is the "Achilles heel" of the nonproliferation system.[8]

Some countries have already declared their right to acquire enrichment and reprocessing technologies. This right is in fact secured for countries party to the NPT. The NPT does not restrict peaceful development and use of nuclear power; Article IV of the Treaty asserts, "Nothing in this Treaty shall be interpreted as affecting the inalienable right of all the Parties to the Treaty to develop research, production and use of nuclear energy for peaceful purposes."

However, in ensuring the right to peaceful use of nuclear energy, the NPT also imposes specific obligations upon its member states. In accordance with Article II of the NPT, "Each non-nuclear-weapon State Party to the Treaty undertakes not to receive the transfer from any transferor whatsoever of nuclear weapons or other nuclear explosive devices or of control over such weapons or explosive devices directly, or indirectly. " Article III requires that each Treaty participant state "undertakes to accept safeguards . . . for the exclusive purpose of verification of the fulfillment of its obligations assumed under this Treaty with a view to preventing diversion of nuclear energy from peaceful uses to nuclear weapons."

The right to develop the nuclear fuel cycle, afforded by the NPT, is considered by some to be a loophole in the nonproliferation regime. This loophole, and recent violations of commonly accepted obligations by certain countries, raises questions about the NPT's capacity to protect international security adequately from threats that may occur.

It would be wrong to blame the authors of the NPT for this loophole. Over the four decades that have passed since the NPT first came into effect, the world has changed dramatically. The NPT to a large extent was initially intended to prevent creation of nuclear weapons by industrially advanced countries such as West Germany, Italy, Sweden, Switzerland, South Korea, Taiwan, and others, while simultaneously providing them the benefit of peaceful nuclear use and security guarantees. When the NPT was being negotiated in the 1960s, hardly anyone could have imagined that, with time, the main actors in proliferation and the dangers arising from it would come to be those countries that had recently become liberated from Europe's colonial dominion (at the time called "developing" or "third-world" countries) and also non-state entities – namely, terrorist organizations.

Considering that objective forces are compelling more and more countries to turn to nuclear energy to satisfy their energy needs, and that they have the right to develop the nuclear fuel cycle, it is necessary to search for solutions that, on the one hand, would prevent proliferation of sensitive nuclear technologies and, on the other hand, would ensure interested countries guaranteed access to *external* sources of nuclear fuel cycle services and products.

In light of the expected broad utilization of nuclear power, the strengthening of the nonproliferation regime should be sought in two ways. One way presupposes that states abandon plans to acquire uranium enrichment and spent nuclear fuel reprocessing technologies if they do not possess them already. However, this proposal has practically no chance to be realized, at least not in the near future. Furthermore, attempts to implement it at present would be counterproductive to strengthening the nonproliferation regime, since it would require amending

the NPT. In other words, the NPT would have to be "reopened," and another discriminatory division among NPT member states – countries permitted to have the nuclear fuel cycle and those not – would have to be created in addition to the nuclear- and non-nuclear-weapons countries division that already exists. Considering the unwillingness on the part of most non-nuclear states to undertake additional restrictions, it is difficult to expect that the negotiations process, involving participation from all 140 NPT member states, would be successful. Many countries believe that restrictions on development of technologies should be universal for all NPT participant states, and should not permit some to develop technologies while prohibiting others. For example, Canada has no enrichment plants at present, although it is considering the possibility of creating an enrichment facility for production of low-enriched uranium for its CANDU reactors. Brazil, which does have an active enrichment program, would be permitted to have it. Efforts to create and enforce this further division would do more to weaken the NPT than it would to strengthen it. As the example of Iran shows, additional division of states into those permitted to have enrichment and reprocessing and those forbidden not only undermines the unity of NPT member countries, but also facilitates development of a black market for nuclear technologies.

The second way to strengthen the regime entails switching to innovative nuclear power technologies that could sustain the nonproliferation regime by means of inherent physical and technological properties. This would require development of new types of power reactors and the fuel cycles for them. To this end, work is presently being conducted through a number of international programs, including the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO), Generation IV, and GNEP+ANFC. However, progress has been slow in these programs, and the possibilities for the creation and use of such innovative nuclear technologies lie in the distant future. Therefore, the expansion of nuclear power in the world, even if started by 2020 to 2025, will be based on the use of light water reactors and existing fuel cycle technologies. Taking into account the current trend toward increasing the operational lifetime of nuclear power reactors up to 60 or 70 years, it becomes obvious that there is a need to find such solutions that could work during a period of at least a century.

In the view of Russian experts, efforts to prevent the spread of enrichment and reprocessing technologies as it relates to the broad expansion of nuclear power should be focused on:

- Creating international institutional barriers;
- Providing assurances of nuclear fuel supply and services; and
- Offering various incentives to newcomer countries from advanced countries supplying nuclear technologies and services.

Taken together, these measures, while not creating legal obstacles for development and use of nuclear power by newcomer countries, would induce them voluntarily to renounce acquisition of nuclear fuel cycle technologies.

Institutional barriers. Institutional barriers require newcomer countries to adhere to a number of binding obligations, without which they cannot expect to get assistance from the nuclear technology supplier countries in developing their

plans for nuclear power. Such obligations may include:

- Acceptance and ratification of the Additional Protocol (1997) with the IAEA on application of advanced safeguards;
- Joining the Vienna Convention on Civil Liability for Nuclear Damage; and
- Creating the legislative basis and organizational infrastructure necessary for operation of a NPP.

A document titled "Milestones in the Development of a National Infrastructure for Nuclear Power" was published by the IAEA in 2007. It enumerates the basic infrastructural elements that a state desiring to use civilian nuclear energy should have. The IAEA makes the decision about a country's readiness to develop nuclear energy, taking into account a country's success in implementing these infrastructural elements. To keep newcomer countries from perceiving these requirements as the creation of another discriminatory regime, it will be expedient for nuclear states to extend the provisions of the 1997 Additional Protocol to their own entire civil nuclear infrastructures.

Assurances of nuclear fuel supply and services. Among the various driving forces behind countries' intentions to acquire nuclear fuel cycle technologies, energy security should be considered the most serious. Therefore, any reasonable and reliable measures in preventing the spread of sensitive nuclear fuel cycle technologies should rely on guaranteed supplies of an entire list of products and services for the civil nuclear fuel cycle, and especially should provide credible access to enrichment services. Without providing these guarantees it will be difficult to expect that states (especially those considered "problematic") be willing to forgo indigenous enrichment capabilities.

It must be noted that from the very beginning of nuclear power utilization the uranium and nuclear fuel market has demonstrated high standards of supply reliability. However, the risk of consumers not receiving nuclear fuel cycle services from the market remains, mainly if supplies are curtailed for political reasons. Therefore, it is necessary to create the conditions in which any country that strictly follows its obligations to comply with the nonproliferation regime should be able to obtain reliable guarantees of reasonably priced supply of fuel cycle services.

In the view of IAEA Director General ElBaradei, these assurances could be made possible through the establishment of multilateral fuel cycle centers, where enrichment and reprocessing activity would be carried out under multinational control.[9] The World Nuclear Association (WNA) Working Group has concluded that a potential strategy aimed at avoiding the spread of sensitive technologies should include "a credible assurance of access to enrichment and reprocessing services" through the strengthening of the existing world market and, in the longer term, "through the establishment of multilateral nuclear fuel cycle centers."[10]

During the past several years, a number of proposals for realizing this strategy have been suggested, including:

- International fuel supply guarantees (the initiative of six countries: France, Germany, The Netherlands, Russia, the United States, and the United Kingdom);
- Creation of enriched uranium reserves (a fuel bank) under the auspices of the IAEA (proposed by the Nuclear Threat Initiative in 2006 and subsequently

endorsed by a Russian initiative in 2007); and

- Creation of a mechanism for the multilateral nuclear fuel cycle (proposed by IAEA Director General ElBaradei), which may be realized both by converting existing national nuclear fuel cycle enterprises into enterprises under multinational control (the enrichment plant in Angarsk, for instance) and by creating new regional multinational centers. For example, for countries in the Pacific and South Asian regions such a center could be created in Australia, which possesses considerable natural uranium reserves. Another center could be created for the countries of the Greater Middle East.

In January 2006, President Putin proposed a Global Nuclear Infrastructure Initiative. The key objectives of the Initiative are strengthening the nonproliferation regime and providing ensured nondiscriminatory access to nuclear energy from all interested parties through the establishment of a network of international centers providing nuclear fuel cycle services (including uranium enrichment) that would be placed under IAEA control.[11] Within the framework initiative, Russia, jointly with Kazakhstan, has established the International Uranium Enrichment Center (IUEC). Subsequently, Russia also offered to include the IUEC in the list of Russian facilities that could be placed under IAEA safeguards, per the safeguards agreement between the Russian Federation and the IAEA.[12]

The Angarsk enrichment plant, which has never produced highly enriched uranium, is currently the smallest of Russia's enrichment plants, with a capacity of only 2.5 million separative work units (SWU)/year. Including the new capacity associated with the Russian-Kazakh joint venture and additional proposed expansion, however, it could reach 10 million SWU/year by 2015. Foreign shareholders will have a right to participate in the center's management, including by having access to all information about prices and contract provisions. They will also be able to contract for deliveries of enriched uranium or enrichment services, and receive a share of the profits. They will not, however, have access to enrichment technology.

The IUEC was legally established as a joint-stock company in 2007 on the basis of the Angarsk enrichment plant. The IUEC is open to participation from any NPT member state that meets nuclear nonproliferation requirements and shares a commitment to the center's objectives. Companies in new member countries are joining the IUEC on the basis of separate intergovernmental agreements between the Russian Federation and the country where each company is located. Currently, a Russian company, TENEX, has 90 percent of shares; a Kazakh company, NAC Kazatomprom, has 10 percent. The plan is that, over time, Russia's shares will drop as new members join. The eventual redistribution of shares in the IUEC is expected to be: Russia's TENEX, 51 percent; Kazakhstan's NAC Kazatomprom, 10 percent; and companies in new member countries, 39 percent.

Up to now, only Armenia and Ukraine have expressed interest in joining the IUEC, with each buying 10 percent of shares. (Their process of joining the IUEC through an exchange of notes has been initiated but not yet finished.) Russia invited Tehran to participate in the IUEC as an alternative to an indigenous Iranian enrichment capability, but Iran rejected this offer. Also,

Russia has extended an offer for India to participate in the IUEC, to help the country secure guaranteed fuel supplies in the future.

Offering various incentives. These early proposals are, in different ways, aimed at the supply side; neither of them touches on the profit motive. It has become apparent that it is also necessary to use mechanisms that induce customers, from an economic standpoint, to renounce acquisition of their own nuclear fuel cycle technologies. This can be done by:

- Offering financial aid and aid in creating a nuclear power infrastructure;
- Supplying reactors for use in black-box mode (for example, supplying low-capacity reactors for desalinating seawater [floating power plants]); and
- Offering packaged contracts.

Such contracts would link the supply of power reactors inseparably with supply of fresh fuel and take back of spent fuel for the reactor's operating life. Contracts that would include removing spent fuel, as well as providing other back-end services, would create far stronger incentives to rely on international mechanisms for fuel supply. The attractiveness of such practices for newcomer countries is not only the fact that they could have guaranteed supply of fresh fuel, but also that they are freed from the problems of disposing of spent fuel, which otherwise presents serious obstacles to national nuclear power development programs.

The contract for construction of the Bushehr NPP in Iran by the Russian company Atomstroyeksport serves as an example of a package agreement to promote nuclear power while minimizing proliferation risks. The construction of the Bushehr NPP was initiated by the German company Siemens in 1975, but was stopped after the Islamic revolution and the Iran-Iraq War. Since then, the United States, convinced that Iran is trying to develop a nuclear weapons capability under the cover of a civil nuclear program, has undertaken efforts to convince nuclear suppliers to refrain from providing any nuclear assistance to Iran and has placed an embargo on supplying high-tech sensitive technologies to Iran. However, Russia, arguing both that each NPT member country has a right to develop and use nuclear power for civil purposes and that the Bushehr nuclear power project posed no proliferation risk, decided to help Iran in its completion, despite U.S. pressure not to do so.

In January 1995, the Russian company Zarubezhatomenergostroy signed a contract with the Iranian organization on nuclear power to complete construction of a light water reactor at Bushehr. Russia also agreed to supply Iran with one nuclear power unit VVER-1000 and the nuclear fuel for it, and to train Iranian specialists to service the reactor. But under U.S. pressure, the Russian government has blocked cooperation with Iran on some sensitive nuclear technologies, including assisting in building a centrifuge enrichment plant.

After details of Iran's clandestine nuclear activities were revealed in 2002, Russia conducted difficult negotiations with Iran, resulting, in February 2005, in a new agreement between the countries. Under this agreement, Russia will supply fresh uranium fuel throughout the Bushehr reactor's first 10 years. For its part, Iran will return the resulting spent fuel to Russia for final disposal. Together, these two parts of the agreement minimize Iran's need to enrich its own uranium as well as eliminate Iran's opportunity to reprocess spent fuel and use extracted plutonium in nuclear weapons. Additionally, through

Russia's insistence, the two countries agreed that any transfers to the Bushehr reactor will be placed under IAEA safeguards.

Iran informed the IAEA that the Bushehr reactor was due to begin operation by the end of 2009, but recently it was announced that launching Iran's Bushehr nuclear power plant is scheduled for March 2010. During 2007 to 2008, Russia delivered 82 tons of nuclear fuel (with enrichment between 1.6 and 3.6 percent U-235) to the Bushehr reactor. The fuel was expected to be loaded into the reactor during the second quarter of 2009.

It seems that practical implementation of all these measures will require continuous efforts over a long period of time. But this strategy, if endorsed by all NPT states in a way that takes into account the national legislations as well as the international obligations of advanced nuclear countries but that does not restrict the rights of newcomer countries, could provide newcomers with a real advantage in implementing plans to use nuclear energy in responding to their energy needs.

ENDNOTES

1 One GWe (gigawatt electric) is equal to one billion watts.

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Steven E. Miller & Scott D. Sagan

Alternative nuclear futures

The global nuclear order is changing, but where is it headed? Will the expected expansion of nuclear power in many regions around the world lead to increased dangers of nuclear terrorism and increased risks of nuclear weapons proliferation? As we noted in our introduction in volume 1,[1] the common answer provided by the diverse international group of contributors to this two-volume special issue of *Dædalus* is that it depends: it depends on how quickly and how widely nuclear power spreads to new countries; it depends on the domestic political and governance characteristics of the new nuclear power states; it depends on whether terrorists' plans to attack nuclear sites or steal nuclear materials succeed or fail; and, crucially, it depends on the steps taken by the international community to improve the safety mechanisms, physical protection standards, and nonproliferation safeguards that make up the tapestry of agreements that we call the nonproliferation regime.

Our colleagues have laid out a rich menu of steps that could strengthen the nonproliferation regime. We hope that governments around the world will listen to the ideas offered by these scholars, industry leaders, and former officials about how best to gain the benefits of nuclear energy while minimizing the security risks that are inherent in the spread of nuclear power. But we know from studying the history of nuclear power and proliferation that not all good ideas are adopted over time, and that wise policies and potential constructive compromises among conflicting interests do not always triumph.

Our crystal ball is not clear enough to predict with confidence whether the global nuclear future will be characterized by peace and prosperity or by conflict and destruction. But we do believe that the choices made in the coming few years will be crucial in determining whether the world can have more nuclear power without more nuclear weapons dangers in the future. Here we first briefly outline five major security challenges posed by the potential expansion and spread of nuclear power. Second, we discuss the major players whose decisions and interactions will determine which policies are adopted and which are rejected as the international community seeks solutions to these five security challenges. Finally, we sketch a number of alternative nuclear futures to demonstrate the truly

momentous nature of the political and technical decisions that will soon be made by critical national and international actors.

What specific challenges to international security are created by the anticipated expansion and spread of civilian nuclear power? Five serious, interrelated problems appear on the horizon: safety, sabotage, terrorist theft or purchase of a weapon or nuclear materials, nuclear weapons proliferation, and destruction of nuclear facilities in a conventional war. Each of these challenges must be addressed if the global expansion of nuclear power is to evolve in desirable directions.

First, will it be possible to ensure that high levels of *safety* are created and maintained in each new power plant as nuclear power spreads? Even the most established and experienced nuclear power states – including the United States, Japan, and Russia – have had accidents in their nuclear facilities. As Richard Meserve notes in his essay in volume 1, these incidents led to the creation of both safer reactor technology and national and international institutions, such as the Institute of Nuclear Power Operators (INPO) and the World Association of Nuclear Operators (WANO), to encourage organizational learning and best safety practices.[2] The stakes here are high, for unless the nuclear power newcomers do even better in maintaining safety than did previous new nuclear power states, we can expect periodic minor accidents and rare but occasional serious incidents. Rapid construction of power plants, weak national regulatory systems, and shortages of trained personnel may exacerbate concerns about safety in the future. Constant vigilance and a high degree of cooperation among all governments and operators will be necessary, as a major accident anywhere would have global repercussions.

Second, will adequate standards for the protection of nuclear facilities against *sabotage* be adopted and implemented as nuclear power spreads? Sabotage can be a gray area since it could be initiated by a disgruntled worker striking out against his or her employer but not meaning to harm coworkers; by an anti-nuclear environmentalist seeking to shut down a power plant; or by a terrorist organization seeking to create a release of radiation and spread fear and panic. All three of these scenarios have occurred in the past, and we see no reason to expect that future sabotage attempts can be eliminated entirely. Fortunately, some measures, such as strong containment vessels and effective personal reliability programs, protect against both accidents and sabotage. The protection of nuclear installations has always been a concern, but the revelation that the 9/11 al Qaeda aircraft hijackers initially considered crashing a jumbo jet into a nuclear power plant heightened the alarm. Continued terrorist interests in targeting nuclear power plants – to create panic, economic damage, and civilian casualties – was demonstrated in the "Toronto 18" case in 2006, in which an Islamic fundamentalist group apparently planned a truck bomb attack against a nuclear power plant in Ontario.[3]

Third, will there be adequate standards of physical protection against a *terrorist theft or purchase* of a nuclear weapon or the materials necessary to make a nuclear bomb or radiological device? Former International Atomic Energy Agency (IAEA) Director General Mohamed ElBaradei has highlighted this danger: "The gravest threat the world faces today, in my opinion, is that extremists could get hold of nuclear or

radioactive materials."[4] The urgency of the physical security problem is well established, as al Qaeda leaders, including Osama Bin Laden, have announced their desire to get nuclear weapons and al Qaeda operatives, such as the British terrorist Dhiren Borat, have been apprehended with plans on how to make and use radiological "dirty bomb" devices.[5] Yet as Matthew Bunn points out in his essay, there is currently no international agreement about what physical protection standards are considered adequate and how much spending is justified in the name of physical security.[6] For some nuclear utilities, security activities too often are seen as a trade off against profit, even though in the long term strong security can prevent successful terrorist incidents that would be incredibly harmful to both company profits and national security. Even in the United States, with more than six decades of nuclear experience, there is still intense and unsettled debate about whether existing standards of physical security are sufficient given the threats that are now thought to exist. As nuclear facilities are built in more states, especially in countries that may have high degrees of corruption and poor regulatory competence, it will be crucial to promote better international standards and implementation of strong physical security measures. New international institutions, such as the World Institute for Nuclear Security (WINS), will need to play an absolutely critical role in promoting best physical security practices between the existing nuclear power states and new states that construct nuclear power plants.

Fourth, will the spread of nuclear power lead to further *nuclear weapons proliferation*? The link between nuclear power and nuclear weapons has been a serious worry throughout the nuclear age. The expansion of nuclear power can lead to the dissemination of expertise and technology that is useful in the weapons context. This will be true particularly if nuclear newcomers acquire the full panoply of technology associated with nuclear power, including fuel cycle technologies that have direct weapons applications. This risk can be limited if the acquisition of uranium enrichment or plutonium reprocessing technologies is discouraged or prohibited. These technologies are, however, also indispensable for the production of fuel for nuclear reactors. Hence, states have to be persuaded that reliable external sources of supply exist before they will agree to forsake the option of national fuel cycle capabilities. States that doubt whether they can trust international suppliers of reactor fuel (whether commercial or multinational) are more likely to think it necessary to acquire their own fuel cycle infrastructure – which means that they will possess a latent nuclear weapons capability. The more states that acquire their own national enrichment or reprocessing capability, the more worrisome the nuclear future will be.

Fifth, there is legitimate concern that a nuclear power plant could be attacked during a *conventional war*, potentially leading to an environmental catastrophe, if, for example, the containment vessel was breached or the spent fuel was attacked and dispersed. Fortunately, some states are acutely aware of this danger and have attempted to mitigate it: India and Pakistan, for example, have agreed not to target each other's nuclear facilities in the event of armed conflict and, as a confidence-building measure, routinely exchange information about their commercial nuclear facilities. Other states, in contrast, have engaged in dangerous attacks during conflicts: during the 1991 Gulf War, for example, Iraq launched a

SCUD missile attack against the Dimona nuclear reactor in Israel, but fortunately lacked the accuracy to hit the intended target. Future "no-targeting" agreements, like the confidence-building measures that India and Pakistan have signed, between new states that have both nuclear power plants and an enduring military rivalry, may be useful.

These five challenges are not the only consequential questions associated with the growth of nuclear power. Questions of finance, of nuclear waste, and of human capital are also important and will have great bearing on decisions about whether states pursue or expand nuclear power, by how much and how quickly. But from a global security perspective, the degree to which the future nuclear order promotes safe, secure, proliferation-resistant, and effectively monitored and governed nuclear power is of paramount importance.

Given these concerns, there are some experts (including some in this special issue[7]) who oppose the further spread of nuclear power on security grounds. There are other experts (again including some in this special issue[8]) who are skeptical about the wisdom of expanding nuclear power worldwide, on grounds that other renewable energy resources will be more effective in combating global climate change. Here we are agnostic on the question of whether there *should be* an expansion and spread of nuclear power in the future. Instead, we simply assume that there *will be* some degree of growth in the use of nuclear energy, including some new states acquiring nuclear power plants. Who will determine which states acquire nuclear technology and how the resulting security concerns are addressed? The fact is that the Nuclear Non-Proliferation Treaty (NPT) regime is, first and foremost, a system of states. Within the governments of those states, however, there are often diverse bureaucratic and political interests affecting nuclear issues. And within those states, the innovators, the providers, the owners, the operators, the sellers, and the exporters of nuclear technology are often found in the private sector.

Accordingly, it is in central governments and corporations around the world where the fundamental decisions are being made that will play the largest role in shaping the future global nuclear order. To be sure, these decisions are not wholly independent of one another. The relevant actors are often influenced by the nuclear policies and programs of others. They are often at least indirectly connected and constrained by varying levels of engagement with the international nuclear marketplace. They are typically participants in the international institutions created to provide some structured governance of the world's nuclear affairs – whether the IAEA and the Nuclear Suppliers Group (NSG) for states or WANO for corporations. They all operate in the context of existing treaty obligations, legal constraints, regulatory requirements, export control guidelines, and normative expectations, however imperfectly the rules-based regime may operate at times. And in a substantially integrated and highly mobile globalized world, the intellectual infrastructure for thinking about nuclear power and nuclear weapons can spread worldwide and produce many common or overlapping frameworks for addressing nuclear issues. Rarely will nuclear decisions be made in complete isolation from these wider realities.

Within this web of potential constraints and influences, however, governments and companies will decide and act on the basis of their own self-defined perceptions, preferences, pol-

icies, and calculations of self-interest. They will make their own judgments about the desirability or unattractiveness of nuclear power as a component of their overall approach to energy. Their choices will determine how fast and how widely nuclear power expands and spreads. As part of its long-term energy strategy, China, for example, has chosen to pursue a policy that will more than double its nuclear power capacity within a decade and that aims to increase that capacity by fivefold or sixfold by 2050. (China currently has 17 nuclear power reactors under construction.) Countries such as Egypt, Jordan, and the United Arab Emirates have already decided to acquire nuclear power plants and other regional powers may follow suit, with the result that the Middle East will become a much more nuclear region.[9] Similar decisions by other states (so-called nuclear aspirant states) will gradually but eventually change the strategic geography of nuclear power on a global scale.

States and firms will also determine, within the constraints of the politicized international nuclear marketplace, which technology paths to follow in developing their nuclear programs. A crucial question for the future is whether the spread of nuclear power reactors will be accompanied by the spread of sensitive fuel cycle technologies that can produce bomb material as well as reactor fuel. There may be international norms and pressures against the acquisition of such worrisome technologies, but ultimately states will choose for themselves. For example, proponents of the nonproliferation regime have long argued that countries like Iran or Brazil do not need, and should not seek, independent uranium enrichment capabilities; however, both of those governments, at least thus far, have decided otherwise. Similarly, the feasibility of proposed international or multinational nuclear fuel cycle arrangements intended to discourage the spread of sensitive weapons-usable technologies will depend on whether states embrace or reject such schemes. Washington, for example, may believe that it is a good idea for Iran to have its nuclear fuel produced in Russia or Western Europe, but Tehran has yet to find the proposal acceptable.

In short, national governments play the central role in shaping the governance of global nuclear affairs. They decide which rules to accept and which to reject, which to respect and which to violate, which are enforced and which are ignored. Whatever constraints or restrictions for strengthening the NPT regime may seem obvious or desirable to the international community of nonproliferation experts, they have no hope of acceptance unless they are found agreeable by the overwhelming majority of states. Similarly, the IAEA is an international organization comprised of member states that provide its funding, oversee its policies, and determine its powers. If the IAEA is to be given additional resources and greater investigative powers, it will be because states have agreed that this should happen.

Within those states, however, different actors often hold different views about which nuclear policies their governments should adopt at home and support abroad. The evolving nonproliferation regime will therefore be strongly influenced by whether supporters of international cooperation and compromise or supporters of national fuel cycle facilities win the debate at home. Fortunately, in many states the central government and industry leaders are committed to the cause of nonproliferation and will act in support of a stronger NPT regime.

Six conclusions follow from this analysis. First, as nuclear power spreads, a growing number of states will become active players in the NPT system. Their investment in nuclear power will mean that they can be directly affected by the functioning of the regime. Moreover, they will be different states. Once, nuclear power was, with a few exceptions, found in the wealthy industrial nations: the United States, Japan, France, and Britain, among others. In the future, many developing countries – Egypt, Iran, Malaysia, Indonesia, and many others – will be in the nuclear power club and will have interests to be defended in the NPT regime. Their views will no doubt sometimes be different from those of the established nuclear power states. The mix of states active in NPT diplomacy will be different than in the past, and these states' decisions will help determine the future global nuclear order.

Second, in an NPT system of 189 states that relies on voluntary commitments by members and that operates generally on a consensus principle, inclusive diplomacy is an imperative if progress is to be made. States need to be persuaded that new rules or reinterpreted norms are desirable and in their interests. The perceptions and preferences of nuclear newcomers need to be understood and taken into account; outreach is essential. States need to believe that they have a stake and a voice in the system or they are unlikely to invest much effort in preserving and strengthening it. This need for broad participation and cooperation is why occasions such as the periodic NPT Review Conferences are so important, despite all their well-known difficulties and problems. They represent the sort of inclusive diplomacy that is necessary if the NPT regime is to be strengthened and if states are to be convinced to choose nuclear policies that are compatible with the needs of the NPT system.

Third, any deviations from the principle of consensus within the NPT regime must be perceived by the majority of states as being legitimate if they are to be effective. This is true regarding both new interpretations of NPT rules and any future efforts to enforce them. As Jayantha Dhanapala's essay in this volume suggests, it is possible that future NPT Review Conferences may adopt a resolution to strengthen the NPT regime, overriding the votes of one or more member states; this could be highly disruptive unless there are widespread perceptions that any such resolutions are fair and legitimate.[10] In his April 2009 speech in Prague, President Obama also emphasized the importance of enforcing nonproliferation commitments:

> Rules must be binding. Violations must be punished. Words must mean something. The world must stand together to prevent the spread of these weapons.[11]

Enforcement decisions, in the UN or in other international institutions are, almost by definition, not consensus decisions, since those states being punished will dissent. The degree to which the vast majority of states, however, views any resulting sanctions or military actions as legitimate and fair enforcement of commitments (as opposed to being raw coercion) will help determine whether the act strengthens or weakens the overall NPT regime in the long term.

Fourth, the points discussed so far highlight the importance of the IAEA and other international organizations. Will the IAEA be able to cope effectively with a world in which there is more nuclear technology spread across more countries? In the design of the nonpro-

liferation regime, the IAEA is intended to play a crucial role in reassuring the international community that civil nuclear programs are not contributing to weapons acquisition. Through a scheme of inspections and safeguards, the IAEA is meant to bring transparency to the world's peaceful nuclear activities and thus to serve as a buffer between peaceful nuclear programs and possible development of nuclear weapons. Across time, the IAEA increasingly has been expected to fulfill the additional role of investigating concerns about the possible existence of clandestine nuclear weapons programs, an issue of obvious importance in judging compliance with the NPT. The IAEA attempts to perform these pivotal roles with limited (many would say inadequate) resources and many political and legal constraints on its ability to act. In his remarkably candid farewell address, IAEA Director General ElBaradei stated, "Our ability to detect possible clandestine nuclear material and activities depends on the extent to which we are given the necessary legal authority, technology, and resources. *Regrettably, we face continuing major shortcomings in all three areas, which, if not addressed, could put the entire nonproliferation regime at risk.*"[12] As nuclear power spreads, the IAEA's challenge will become even more demanding and the shortfalls could become even more acute. A crucial question for the future of the nuclear order is whether the member states that fund the IAEA and determine its legal mandate will be prepared to strengthen the Agency so it is adequate to its responsibilities in a more nuclear world. If not, one of the principal barriers between energy production and weapons programs will be seriously weakened.

Fifth, an important determinant of future proliferation will be the degree to which the spread of the nuclear power industry produces civilian nuclear power bureaucracies in different states that want to maintain peaceful programs and oppose turning civilian energy programs into nuclear weapons programs. Indeed, how best to ensure that civilian nuclear power bureaucracies maintain a strong interest in opposing nuclear weapons proliferation may be the $64,000 question for estimating the effect of the global spread of nuclear power on the likelihood of nuclear weapons proliferation. This is ironic, for although some nonproliferation specialists may not want more countries to start nuclear power programs, once those states do so, it will be important for nonproliferation that their nuclear power programs are successful. The leaders and bureaucratic organizations that run successful nuclear power enterprises will want to maintain strong ties to the global nuclear power industry, to international capital and technology markets, and to global regulatory agencies – and hence will be more likely to cooperate with the nuclear nonproliferation regime. Leaders of less successful or struggling nuclear power enterprises, in contrast, might be more likely to support clandestine or breakout nuclear weapons development programs as tools to justify their existence, prestige, and high budgets within their state. Research on Japan and South Korea, for example, has shown that the liberalizing governments supported maintaining their close relationship to global markets and institutions and that this decision influenced the capability and willingness of nuclear bureaucracies to push for weapons programs. In the case of India, by contrast, the power and autonomy of the state's "strategic enclave," coupled with the record of failure in producing nuclear energy, strongly encouraged the leaders

of India's nuclear bureaucracies to lobby Indira Gandhi to test a weapon in 1974, to encourage the Bharatiya Janata Party (BJP) to test another set of weapons in 1998, and to oppose constraints on their ability to test new nuclear weapons today.[13]

Sixth, and finally, a critical factor shaping our nuclear future will be whether leaders in the non-nuclear-weapons states (NNWS) see the NPT merely as an effort to get the nuclear-weapons states (NWS) to disarm, or whether they conceive of the NPT as a solution to a collective action problem. This clearly was part of how leaders conceived of the NPT when they signed and ratified it in the late 1960s and subsequently. The Treaty and the IAEA inspection regime it created were valued because they provided a sense of confidence that other states in the region were not developing nuclear weapons and that, therefore, the state in question could renounce nuclear weapons as well. But over time, that vision was lost, and many NNWS began to see the NPT as merely an unfair constraint on them and as a largely unsuccessful goad to encourage nuclear disarmament in the NWS. The possibility of international control of the nuclear fuel cycle, and the accompanying constraint on national nuclear fuel production programs, will be more likely if all nuclear power states see a danger in their neighbors operating sensitive nuclear fuel facilities. This perceived fear may make states more willing to accept international control of the nuclear fuel cycle, and the constraints on their national programs that come along with it, in exchange for constraints on their neighbors' programs.

Many possible outcomes could arise from the complicated, unpredictable, decentralized process of nuclear decision-making. Expectations have often been confounded and predictions have often been wrong. The notion of nuclear electricity "too cheap to meter," for example, has long ago faded into history. Forecasts that there would be dozens of nuclear-armed states have fortunately proven wrong (so far). Previous predictions that there would be a rapid expansion of nuclear power around the globe turned out to be wildly off the mark. Though we can see today features of the nuclear landscape that will materialize well into the future, it is not easy to predict what the global nuclear order will be. A long legacy of incorrect predictions should keep us humble and remind us that we, too, can be wrong. It is possible, however, to envision how things might turn out if things go well or badly.

The most optimistic vision of the future sees the substantial expansion and spread of nuclear energy use around the globe, but with effective constraints placed on the potential adverse security consequences. There would be many more nuclear reactors on a global scale, contributing to the mitigation of climate change and to energy security, but fuel cycle capabilities would not have spread. Nuclear newcomers would rely on international arrangements for the fuel to run their reactors and would use international or regional repositories to store spent fuel, rather than hold it or reprocess it at home. In this way, the link between nuclear power and nuclear weapons could be limited. Ideally, further reassurance about the purely peaceful applications of the world's additional investments in nuclear power would be provided by a larger, stronger, better funded IAEA, presiding over a regime that institutionalized high levels of transparency and empowered the IAEA with sufficient investigative powers to produce confidence that cheaters will not undermine

the regime. If the international governance of the world's nuclear affairs can evolve and strengthen, then it may be possible to establish and promote compliance with high common standards for safety and physical security – for example, through the refinement and enforcement of UN Security Council Resolution 1540, which already calls on states to ensure "appropriate and effective" levels of security at their nuclear facilities (but without ever defining what steps meet that standard). It will never be possible to eliminate all risk, of course; but the world would be a safer place if all states possessing nuclear technology were not only obliged to accept desirable standards, but made more genuine and monitored efforts to meet those standards. A system that possessed this set of attributes would be a robust nonproliferation regime that would allow the wide exploitation of nuclear power while circumscribing the potential risks and problems associated with nuclear power.

The likelihood of reaching this nuclear future would be increased if steps were taken to delegitimize and marginalize nuclear weapons and if the NWS were judged to be making sincere efforts to move toward nuclear disarmament in fulfillment of their obligations under Article VI of the NPT.[14] It is difficult to dampen the appetite for nuclear weapons when existing NWS enshrine those weapons at the center of their security policies, tout the unique and indispensable security contributions of these weapons, and proclaim their intention to retain nuclear weapons for the indefinite future. It is also difficult to credibly call for a strictly enforced rules-based nonproliferation system when the NWS are seen to be flouting their own obligations under the nonproliferation regime. It is too soon to tell where the arms control initiatives launched by President Obama, notably in his nuclear disarmament speech in Prague in April 2009, may lead, but even the first small steps seem to have had a positive impact on the climate of opinion in nuclear affairs. If there is progress toward deeper cuts in nuclear forces, if the NWS begin to reduce their reliance on nuclear weapons, and if there is success in putting into place other measures such as the Comprehensive Test Ban Treaty and the Fissile Material Cutoff Treaty, then nuclear weapons would seem less valuable and the incentive for new states to acquire them would diminish. This shift would be a useful buttress to a more extensive and effective nuclear nonproliferation regime.

A much more negative vision of the future finds that the global expansion of nuclear power has produced an array of undesirable consequences. If nuclear newcomers lack confidence in the international market for nuclear fuel, however it is configured, some will surely seek to master the nuclear fuel cycle themselves (as Iran has done) in order to ensure a reliable supply of reactor fuel for their nuclear programs and, perhaps, to maintain a weapons option for the future. Neighboring states will be nervous, great powers will be alarmed, and friction is likely to ensue – as evidenced in the past decade in the cases of Iraq, Iran, Libya, and North Korea. Coping with this problem will be even worse if the standing of the IAEA were to erode and its ability to provide transparency and reassurance were undermined. It is certainly possible that in the future the IAEA, hobbled by inadequate resources, handicapped by its limited legal mandate, partially blinded by the lack of its own intelligence capabilities, tainted by the political maneuverings of member states, harmed by past failures, and crip-

pled by the defiance of troublesome states, would be judged insufficient, incapable of addressing the challenges of a more nuclear world. The IAEA has its critics even today, but its problems could easily be compounded in the future. If the IAEA were no longer regarded as an effective tool in the nonproliferation regime, this would weaken another barrier that stands between nuclear power and nuclear weapons. In the event that the nonproliferation system seems to be breaking down, institutionalized efforts to provide global governance in the nuclear realm are also likely to decay or fail. In a world in which states are aggressively pursuing their own nuclear interests and the institutions and mechanisms of nonproliferation are weakening, rules are less likely to be accepted, respected, or enforced. The evolution toward universal high standards for safety and physical security would be stifled and the result could be very uneven safety and security efforts in national nuclear programs – meaning higher risk of accident or incident.

The most disturbing variant of this negative vision for the nuclear future would be one in which the norm against acquisition of nuclear weapons is fractured and new NWS emerge. States that determined for their own self-interested reasons to acquire nuclear weapons could defy or ignore the NPT/IAEA system or simply withdraw from the NPT (as North Korea did). In conflict-prone regions in which fuel cycle capabilities exist in multiple states, there arises the possibility of the competitive pursuit of nuclear weapons (as occurred in South Asia between India and Pakistan). If enrichment and reprocessing are more widely distributed across states, acquisition of nuclear weapons by one power could more easily trigger nuclear acquisition by others. In the past, rapid cascades of proliferation – though sometimes predicted – have not occurred and are not certain to occur in the future.[15] But the dynamic could well be different if the nonproliferation regime is thought to be eroding and more NNWS possess the latent capability to manufacture nuclear weapons. The reassuring record of a past era marked by few NWS, a sturdy norm against acquisition, a reasonably sound nonproliferation regime, very infrequent spread of nuclear weapons to new states, and possession of fuel cycle capabilities by only a few states may not be a reliable guide to the future if trends slide in a negative direction. Decades ago, Henry Rowen and Albert Wohlstetter famously worried about the dangers of "life in a nuclear-armed crowd."[16] Decades hence, we could find ourselves living in that world if unwise choices and unfortunate preferences lead us down an undesirable nuclear path.

Momentum toward a proliferated world would be reinforced if the current NWS fail to move away from reliance on nuclear weapons. The notable cooling in U.S.-Russia relations could plausibly lead to a restoration of their nuclear rivalry and to a resurrection of nuclear deterrence as the centerpiece of the strategic relationship between the world's two largest nuclear powers. Indeed, both powers retained substantial nuclear arsenals postured at least in part to "hedge" against the possibility that hostility would resume in their bilateral relationship. The nuclear obsession that marked the Cold War could return. But even if that does not happen, both the United States and Russia have continued to embrace nuclear weapons and to adopt doctrines and defense policies that accord a prominent role to nuclear weapons. If the arms con-

trol process sputters and breaks down, if multilateral agreements founder and fail to enter into force because of strenuous opposition within NWS, if the articulated commitments to nuclear disarmament come to be regarded as false promises, then relations between nuclear haves and have-nots are likely to be difficult and the international atmosphere will be more conducive to the spread of nuclear weapons.

A third vision of the nuclear future would involve a collapse of the expected nuclear renaissance and a possible contraction of the role of nuclear power. It would not be the first time that an expected nuclear renaissance did not happen. This could come about in two ways, one benign and the other dystopian. It is possible that the economic costs and security challenges will in the end outweigh the incentives to expand nuclear power. Perhaps alternative energy sources will develop more rapidly than expected or some technological innovation will make nuclear power seem less necessary or less competitive. Perhaps it will be possible to address the world's energy and climate change challenges without additional exposure to the risks and challenges associated with nuclear power. This would be the benign route to a more circumscribed future for nuclear power.

The darker scenario involves failure to contain successfully the risks of nuclear power. The anticipated expansion and spread of nuclear technology could be derailed if something horrible happens. The catastrophic reactor accident at Chernobyl set back the nuclear sector by decades in some countries; another large accident would likely have similar effects. A breach of physical security at a nuclear installation that resulted in a serious sabotage incident or terrorist possession of nuclear materials or weapons undoubtedly would dampen the enthusiasm for nuclear power expansion and cause some recalculation of the cost-benefit equation. And then there is the most horrible scenario of all: the use of nuclear weapons. A nuclear detonation in a city or against any other target would clearly alter the global nuclear debate and produce a more constrained nuclear power future.

The global nuclear future is highly uncertain, and there is no reason to assume that a desirable nuclear order will arise automatically or spontaneously. Men make their own history, but they do not make it entirely as they please, Karl Marx famously noted. Governments, the nuclear industry, and international institutions will make our nuclear future, but their complex interactions may not produce the nuclear world that each of them seeks. This is why it is so important to think hard now about where we may be headed, what desirable outcomes we should seek, and what steps should be taken now to increase the likelihood of a safer and more secure nuclear order in the years ahead.

ENDNOTES

[1] See Steven E. Miller and Scott D. Sagan, "Nuclear Power Without Nuclear Proliferation?" *Dædalus* 138 (4) (Fall 2009): 7–18.

[2] Richard A. Meserve, "The Global Nuclear Safety Regime," *Dædalus* 138 (4) (Fall 2009): 100–111.

[3] See Colin Perkel, "Terror Cell Co-leader Pleads Guilty," *The Canadian Press*, October 8, 2009, http://ca.news.yahoo.com/s/capress/terror_guilty_plea; and Melissa Leong, "Fertilizer, Remote Detonators Figure in Terror Plot," *Canwest News Service*, May 30, 2008.

[4] Mohamed ElBaradei, "Statement to the Sixty-Fourth Regular Session of the United Nations General Assembly," November 2, 2009.

[5] See U.S. Regulatory Commission, "Backgrounder on Dirty Bombs," July 30, 2009, http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/dirty-bombs-bg.html.

[6] Matthew Bunn, "Reducing the Greatest Risks of Nuclear Theft & Terrorism," *Dædalus* 138 (4) (Fall 2009): 112–123.

[7] Robert H. Socolow & Alexander Glaser, "Balancing Risks: Nuclear Energy & Climate Change," *Dædalus* 138 (4) (Fall 2009): 31–44.

[8] Harold A. Feiveson, "A Skeptic's View of Nuclear Energy," *Dædalus* 138 (4) (Fall 2009): 60–70; and José Goldemberg, "Nuclear Energy in Developing Countries," *Dædalus* 138 (4) (Fall 2009): 71–80.

[9] See *Nuclear Programmes in the Middle East: In the Shadow of Iran* (London: International Institute for Strategic Studies, 2008).

[10] See Jayantha Dhanapala, "The Management of NPT Diplomacy," in this volume. See also, Cecilia Albin, *Justice and Fairness in International Negotiation* (Cambridge: Cambridge University Press, 2001).

[11] U.S. President Barack Obama speaking in Prague, April 5, 2009.

[12] ElBaradei, "Statement to the Sixty-Fourth Regular Session of the United Nations General Assembly," emphasis added.

[13] See Etel Solingen, *Nuclear Logics: Contrasting Paths in East Asia and the Middle East* (Princeton, N.J.: Princeton University Press, 2007); and Itty Abraham, *The Making of the Indian Atomic Bomb: Science, Secrecy and the Postcolonial State* (London: Zed Books, 1998). See also George Perkovich's essay, "Global Implications of the U.S.-India Deal," in this volume.

[14] See Scott D. Sagan, "The Case for No First Use," *Survival* 51 (3) (2009): 163–182.

[15] See William C. Potter's essay, "The NPT & the Sources of Nuclear Restraint," in this volume.

[16] See Albert Wohlstetter, Thomas A. Brown, Gregory Jones, David McGarvey, Henry Rowen, Vincent Taylor, and Roberta Wohlstetter, "Moving Toward Life in a Nuclear Armed Crowd?" Report for the Arms Control and Disarmament Agency, April 22, 1976, http://www.npec-web.org/Frameset.asp?PageType=Single&PDFFile=19751204-AW-EtAl-MovingTowardsLifeNuclearArmedCrowd&PDFFolder=Essays.