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## ENERGY AND SECURITY IN NORTHEAST ASIA: PROPOSALS FOR NUCLEAR COOPERATION

*by Susan L. Shirk and Michael Stankiewicz*

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Gaining access to energy resources has long been a source of contention among established and rising powers. IGCC Policy Papers 35-37, *Energy and Security in Northeast Asia*, examine the significance of Northeast Asia's rising energy demands on regional and global energy and security politics.

In Policy Paper 35, Kent Calder and Fereidun Fesharaki debated the fundamental issue of whether rising energy demand generates new security dilemmas or whether efficient energy markets mitigate potential security risks arising from increased competition for energy resources. Calder argued that energy rivalry might deepen tensions among the major powers in Northeast Asia. Fesharaki sees manageable market competition where Calder sees more fundamental rivalries.

In Policy Paper 36, Fesharaki and his colleagues at the East-West Center's Program on Resources, Energy, and Minerals examined supply and demand projections of fossil fuel usage and argued that markets can solve looming energy crises, obviating the need for multilateral solutions. Their analysis of the inefficacy of certain proposals for regional cooperation regimes based on intra-regional pipelines suggests caution about the prospects of current proposals for multilateral cooperation, highlighting the enormous political and social distrust in the region—the basis of Calder's fears about regional tension and rivalry.

Policy Papers 35 and 36 contain two common themes. The contributors to both noted the increasing primacy that Asian economies place on nuclear power as a future energy source, especially relative to the dwindling post-Chernobyl and Three Mile Island nuclear programs elsewhere. They also provided evidence supporting Calder's proposal that energy rivalry not only provides potential for major power tension, but also the opportunity for major power cooperation. In this era of cheap oil supplies and even cheaper development technologies, and with all of the governments in Northeast Asia maintaining a primary goal of economic growth and higher standard of living for their constituents, Northeast Asia has a shared priority in guaranteeing safe, stable energy supplies without risking the shortages that historically led to competition and conflict.<sup>1</sup>

Policy Paper 37 introduces prominent proposals for multilateral Northeast Asian nuclear energy cooperation advanced by Kaneko Kumao, Suzuki Atsuyuki and Jor-Shan Choi (an analysis by Suzuki Tatsujiro about lessons from the European experience (EURATOM) appeared in IGCC Policy Paper 24, *Energy and Security in Northeast Asia*).<sup>2</sup> Cooperation on nuclear energy would have a direct impact on political and security relations among Northeast Asian states. Nuclear power is an attractive alternative for all the Northeast Asian states, especially Japan and South Korea, which have no energy resources of their own and have to import all their fuels. Nuclear energy is much cleaner than that extracted from fossil fuels, and it is a symbol of technological modernity.

Nuclear programs raise a series of issues that transcend national borders, including the safety of nuclear energy production; the dangers associated with reprocessing (i.e., risk of diversion for military purposes), the challenges of disposal of spent fuel and nuclear waste, and safety issues related to the security of nuclear materials and facilities. Therefore, it is not surprising that as nuclear energy has developed in Northeast Asia, there has been a parallel growth of multilateral cooperative initiatives, including from governments in the region.<sup>3</sup> However, it is not clear that these efforts have yet addressed the full range of concerns encompassed by what the International Atomic Energy Agency (IAEA) calls the "new realities" of the fuel cycle.<sup>4</sup>

Although some proposals for regional nuclear power cooperation include technical assistance on the operation of power plants, particularly dealing with safety, all of them

concentrate on the problem of the disposal of spent nuclear fuel (please see Appendix A for a description of this, related to what is known as the back end of the nuclear fuel cycle). Each country building nuclear power plants faces the challenge of disposing of radioactive wastes. The political problems of siting such waste repositories are immense, and the international community, particularly the United States, worries about having the waste recycled into military uses. For China, Japan, South Korea, Russia, and possibly North Korea to devise a joint solution to the waste disposal problem by establishing a regional temporary or permanent storage site in some remote area would ease fears of nuclear threats and enhance trust throughout the region. For example, public concerns about Japan's excess plutonium supplies emanating from its recycling program would disappear if Japan stored this plutonium in a regional repository, with regional and global safeguards and real-time monitoring--accounting for all waste at all times.

Together, Kaneko, Suzuki, and Choi shed light on the diverse range of actors initiating activity in this topic. As Edward Fei characterizes in his analysis of the three proposals, Kaneko's approach is shaped by his long and distinguished career as a diplomat, seeking to develop regional confidence-building measures in a part of the world where major powers lack trust. Kaneko delves into the country-specific problems faced by each Asian country with a civilian nuclear weapons program, conceding that global regimes such as the IAEA or the Nuclear Non-Proliferation Treaty (NPT) are not sufficient to address the region's suspicions regarding neighbors' nuclear programs. Iraq and North Korea are examples where IAEA safeguards were insufficient, and the NPT lacks sanctions against violators. Kaneko proposes a regional ASIATOM that would include annual meetings of ministerial-level government representatives, an ASIATOM committee to oversee operations, and functional/technical committees comprised of nuclear technicians. Three centers are proposed, focusing on safety, storage, and research and development. But Kaneko emphasizes that the key aspect of any ASIATOM would have to include a regional safeguards/ inspection system administered by ASIATOM representatives that would complement the existing insufficient NPT/IAEA safeguards.

Suzuki's less ambitious proposal belies the perspective of an academic, one of the leading nuclear experts in the region. Suzuki, who was recently named to head up the reform committee of the PNC, Japan's national nuclear program, proposes a regional intermediate storage facility for deep underground storage until long-term issues regarding NIMBY (not in my backyard) concerns are resolved. This would harness the collective financial and technical resources of Northeast Asian countries to solve short-term storage concerns until permanent solutions are devised, either technically or politically, in the next 50 years. In addition, Suzuki suggests a regional facility devoted to research for underground geological nuclear waste disposal, which would be devoted to overcoming technical concerns about permanent underground storage and--more importantly-- engage in public education about the safety of geological disposal to overcome NIMBY resistance.

Choi lays out the wide realm of possibilities for technical cooperation based on his extensive background as a nuclear engineer. Choi's chapter provides the most extensive documentation about the current status of Northeast Asia's civilian nuclear weapons programs, including the governments' current plans for waste disposal. He identifies many of the same problems that Kaneko does, and supports the formation of a regional cooperative framework soon to resolve current problems hindering civilian nuclear power development in Northeast Asia. Unlike Kaneko, Choi chooses no specific name, such as ASIATOM, but narrows initial membership from all Asian countries to just those areas currently possessing nuclear programs (China, Japan, North and South Korea, Taiwan, and the Russian Far East). Choi argues that while the six areas share proximity, mutual security interests, interdependent economic objectives, and common energy needs, their distrust stemming from historical hostilities, potential military and territorial disputes, and competition for natural and energy resources makes it vital that the most likely catalyst of such a regime, the United States, be a member too. Choi's proposed compact includes many of the same features suggested by Kaneko and Suzuki: radioactive waste management, nuclear non-proliferation safeguards, safety, and economic cooperation. What distinguishes Choi's proposals is its fixed three-year period devoted to dialogue and information exchange about a regional nuclear compact. Energy policy planners, nuclear experts, nuclear industry representatives, foreign ministry officials, and defense ministry officials would all participate in track two meetings (with government officials participating in their

private capacities, not as representatives of their government) devoted to overcoming barriers and concerns about a regional compact. At the end of the three-year period, the appropriate governments then would face a decision about whether or not an East Asian regional nuclear compact is feasible and should be implemented. This eases prototypical concerns in Northeast Asia about premature institutionalization.

Discussions of plans for possible nuclear power cooperation in Northeast Asia are at an early stage. Whether they ever materialize depends largely on the policies of the U.S. government. At present, Washington officials remain ambivalent: On the one hand, they see the positive value for peace and security of regional nuclear cooperation. On the other hand, they are leery of any regional policies that in effect encourage countries to build nuclear power plants because these plants produce material that can be used to build nuclear bombs. From this perspective, the best guarantee against proliferation would be to discourage nuclear power altogether.

In Policy Paper 37, Fei, of the United States Department of Energy, offers a summary and critique of the proposals by Kaneko, Suzuki, and Choi, in which he focuses on their political feasibility. Fei points out the limitations of Kaneko's and Choi's top-down approach to nuclear cooperation based on establishing organizations to lead nuclear cooperation. In Suzuki's proposal, Fei highlights the benefits of understanding the role that utilities play in nuclear programs, of establishing a scheme that aligns Japanese and American interests, and recognizing the potential gains of postponing a decision on permanent storage of nuclear waste by settling on an interim plan. Finally, Fei notes that while the proposals highlight the important role the United States plays in nuclear policy in the region--Choi and Suzuki emphasize the importance of US involvement, while Kaneko sees US leadership as a hindrance to regional cooperation--none adequately address the complex role that China must play in this field if nuclear cooperation is to become a regional confidence building measure (CBM).

IGCC Policy Papers 35-37, *Energy and Security in Northeast Asia*, examine the energy-security connection in Asia with an eye towards a greater challenge. As exemplified by the papers in this volume, numerous energy experts and technicians believe multilateral cooperation can help Asia meet its rising energy demand, especially in an era of low-cost availability of fossil fuel resources. However, as noted by Calder, many diplomats are struggling with efforts to increase confidence among Northeast Asian nations, to mitigate what are seen as a potentially explosive set of security conditions in the region.

Both sets of actors, technical and diplomatic, have viable goals, but without joining forces, neither has had the political will to move forward. Perhaps together they do? If technical collaboration is seen as a CBM, then skepticism about technical merit may not be as important. It can be argued that cooperation *per se* on technical issues will not necessarily yield political spillovers. But two reasons distinguish cooperation on nuclear energy as a vital first-step CBM in Northeast Asia. First, it is only through multilateral cooperation that the fundamental concerns about nuclear energy (dwindling capacity for waste storage and suspicions related to potential diversion of weapons-grade material for military purposes) can be resolved. There is no other viable alternative that can be achieved unilaterally or even bilaterally. Second, other efforts at multilateral CBMs in Northeast Asia have proven to be too sensitive, too premature, with aversion to the institution-building that accompanied multilateral security in Europe.

If other CBMs are premature, maybe cooperation on nuclear issues is a good test case for confidence-building among the major powers in Northeast Asia, of beginning to overcome the region's deeply-held suspicions arising from the 20th century's history of acrimonious relations? One example of the political benefits of technical collaboration is the United States-Russia lab-to-lab program, which developed trust and confidence at the grass-roots level through dialogue and exchange between the countries' leading nuclear weapons lab technicians, eventually paving the way for political, technical, and financial cooperation on nuclear weapons disposition.

One theme works its way throughout *Energy and Security in Northeast Asia*: Only when diplomatic policymakers--such as those involved in NEACD--join the dialogue of technical experts focusing on multilateral energy cooperation will these proposals gain the political acceptance necessary to justify the national risks associated with their implementation.

## *Endnotes*

1. Oil prices sank to their lowest price in real terms in history when they hit \$10/barrel in early 1998.
2. Many papers in this collection first were presented to a September 1996 Northeast Asia Cooperation Dialogue (NEACD) workshop on Northeast Asian energy and security held in Seoul, Korea. IGCC founded NEACD in 1993 as an informal track-two dialogue exploring the potential for cooperation on security issues among China, Japan, Russia, the Republic of Korea, the Democratic People's Republic of Korea, and the United States. This workshop on energy and security offered participating government officials and private experts an opportunity to explore the ramifications of increasing energy demand on future relations among their countries. After the workshop, IGCC solicited additional papers to fill gaps and analyze basic premises among our initial contributions. Permission to reprint Appendix A: Nuclear Power Technology and The Nuclear Fuel Cycle, *Nuclear Power Generation and Fuel Cycle Report 1997*, Washington, DC: Energy Information Administration, pp. 43-46, granted by the U.S. Department of Energy.
3. See CSCAP (Council for Security Cooperation in the Asia Pacific) Working Group Report, *Asia Pacific Multilateral Nuclear Safety and Non-Proliferation: Exploring the Possibilities* (December 1996). For example, the idea of an Asia Nuclear Safety Consultation Organization (ANSKO) was first raised by South Korea at the September 1992 36th General Conference of the IAEA. This proposal was refined over successive years but is still considered "premature" by many governments (especially Australia and China) when it was last discussed at the October 1997 Seoul Conference on Nuclear Safety in Asia.
4. For details on the IAEA "new realities," as proposed by IAEA Director General Hans Blix, please see Edward Fei's chapter in this volume, "*New Realities of Nuclear Energy: Analyzing Three Proposals for Cooperation in Asia.*"

# Nuclear Energy and Asian Security in the 21<sup>st</sup> Century: A Proposal for ASIATOM

by Kumao Kaneko

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“We must all hang together, or assuredly we shall all hang separately.”  
---Benjamin Franklin

## Three Big Waves in Asia

Asia, particularly East Asia, has long been considered as the center of the world's economic growth. Nowhere is this phenomenon more evident than in the field of nuclear energy development. In sharp contrast to protracted stagnation in the rest of the world, nuclear energy in Asia is gaining ground steadily as countries in the region continue to grow economically and their needs for electricity keep expanding. If all of the planned nuclear power development programs of these countries are implemented, approximately 170 nuclear reactors--more than one-third of those in the world--will be operating in Asia by 2025.<sup>1</sup> This trend is neither new nor unforeseen. In retrospect, there have been three "big waves" of peaceful use of nuclear energy in Asia in the past 40 years.

The first wave hit Asia in the mid-1950s when U.S. President Dwight Eisenhower made his "Atoms for Peace" proposal in a historic U.N. speech in December 1953. In an effort to globally promote the peaceful use of nuclear energy, the United States distributed, as part of its post-war economic aid, small TRIGA II type research reactors to many Asian countries which showed interest in the proposal. It was generally surmised that the United States intended to monopolize the world nuclear market ahead of its European rivals.

In response to this American overture, several countries in Northeast Asia--Japan, Korea (ROK) and Taiwan (ROC)--all poor in indigenous energy resources, decided to avail themselves of this opportunity to develop a novel, seemingly attractive energy for peaceful purposes. The first steps were sending their young, promising technicians to the United States and Great Britain for advanced education and training, while importing nuclear fuels, reactors and other materials from abroad. In the case of Japan, it was not an easy decision since most of the people had not yet fully recovered from the traumatic experience of Hiroshima and Nagasaki only 10 years earlier. But Japan quickly enacted the Basic Law on Atomic Energy in December 1955 and established the Atomic Energy Commission one month later. The first experimental power reactor, JPDR, started operation in October 1963, to be followed by *Tokai No. 1*, which began commercial operation in 1966, only 13 years after the "Atoms for Peace" proposal.

Korea and Taiwan followed suit, with the former's *Kori No. 1* and the latter's *Chinshan No. 1* starting commercial operation in 1970 and 1978 respectively. But Southeast Asian nations held off on nuclear power generation during this period, even though interested in non-power uses of nuclear energy such as the application of radio-isotope and irradiation for medical, agricultural and other industrial purposes.

The second big wave arrived with the first Oil Crisis in the wake of the Middle East War of October 1973. In desperate efforts to reduce their excessive dependency on imported oil, many countries in Northeast Asia stepped up development of their nuclear power programs, this time joined by a few countries in Southeast Asia (notably the Philippines and Thailand) that lacked indigenous energy resources.

While the Thai nuclear power program was suddenly dropped halfway before implementation at the end of the 1970s when off-shore natural gas was discovered in the Gulf of Thailand, the Philippines under President Marcos' aggressive leadership began constructing its first nuclear power plant in Bataan Peninsula with two light-water reactors (LWR) imported from Westinghouse in the United States. However, the Philippine program was delivered a fatal blow

by an accident that happened at Three Mile Island (TMI), Pennsylvania in March 1979; the construction of the two reactors at Bataan--one of them nearly completed by that time--had to be abandoned amid the financial scandal caused by the accident. The price of the two reactors almost doubled from \$1 billion to \$1.9 billion after the accident because of the more demanding nuclear safety standards set by the U.S. Nuclear Regulatory Commission in the aftermath of the TMI accident.<sup>2</sup> The Philippine government recently decided finally to mothball the reactors while their non-nuclear portions will be converted to a conventional thermal power plant.

But the momentum for nuclear power created by the second wave following the two oil crises during the 1970s was short-lived even in those Northeast Asian countries already advanced in nuclear power programs. One of the biggest negative factors contributing to this was the "peaceful" nuclear explosion by India in May 1974 and the subsequent adoption of tighter non-proliferation policies by the United States and other nuclear suppliers (e.g., Canada and Australia).<sup>3</sup>

While Japan alone managed to maintain its original nuclear fuel cycle program, particularly the reprocessing of spent nuclear fuels and plutonium recycling, through long and hard diplomatic negotiations with the United States, Canada and Australia (for which I was directly responsible as the first Director of the Foreign Ministry's Nuclear Energy Division), both Korea and Taiwan suffered from these external factors. Korea, which had planned to build a reprocessing capability similar to Japan's, was forced to suspend its recycling program under heavy pressure from Washington for security reasons. The problems facing Korea and Taiwan remain basically unchanged to this day as will be examined in the next section.

The third and current wave emerged in the early 1990s with the end of the Cold War. The countries of Southeast Asia, especially ASEAN, had attained a remarkably high level of economic development, thereby winning the flattering title of "the world's growth center." The economic expansion in most of East Asia is increasing the needs for energy, including nuclear energy for electricity. This latest phenomenon is unique to East Asia compared to Europe and North America, where nuclear industry remains crippled, if not totally moribund, under the dark shadow of the two major nuclear accidents, TMI (1979) and Chernobyl (1986).

## Expanding Nuclear Power in Asia

Today, more than half a dozen countries in Asia, including newcomers like China and countries in Southeast Asia, are making determined efforts to use nuclear power as an alternative source of energy to meet long-term demands for electricity. An additional justification for more nuclear energy is related to environmental problems, especially global warming, climate change, and acid rain allegedly due to carbon-dioxide and sulfur-dioxide emitted from fossil fuels.

On the other hand, the enhanced environmental awareness is likely to stir popular skepticism and distrust about nuclear energy. This is posing serious concerns for most countries, both already engaged or about to be engaged in nuclear power. Let me briefly survey the situation within Asia.

In Northeast Asia, Japan, with 51 reactors generating approximately 43GWe (33%) of the country's electricity production, is planning to double its reactors by 2010 to produce more than 75GWe (42%) of electricity demand. This is believed necessary, as repeatedly stressed by the government and the utilities, to fulfill Japan's obligations to reduce its level of dependency on imported oil and reduce its level of carbon-dioxide emission in the atmosphere.

Japan emitted 4.9% of the world's total CO<sub>2</sub> emissions in 1992, at the time the world's fourth largest polluter, and Japan ranked sixth in terms of per capita CO<sub>2</sub> emissions. It was agreed among the members of the Global Warming Prevention Convention that CO<sub>2</sub> emissions of each member should be stabilized by 2000 at 1990 levels. According to an estimate published by the Environment Agency in January 1997, Japan's CO<sub>2</sub> emissions in 1996 amounted to 345 million tons--7.8% more than in 1990. It is generally believed that it has now become even more difficult--nearly impossible-- for Japan to fulfill its international obligations to reduce CO<sub>2</sub> emissions by

2000 unless drastic measures are introduced. Amid general pessimism, nuclear energy is considered one of the few alternatives that can help meet this requirement.<sup>4</sup>

But two recent PNC accidents--the sodium leakage accident of the prototype fast breeder reactor *Monju* in December 1995 and the fire/explosion accident at the *Tokai* reprocessing plant in March 1997--have seriously damaged popular confidence in nuclear energy, as revealed in the results of the August 1996 Maki municipal referendum, the first of its kind in Japan. This will further delay Japan's program of plutonium recycling in FBRs and light water reactors (LWR), causing another serious problem with international implications: Japan's increasing stockpile of separated plutonium.

Korea, the second largest nuclear-energy country in the region with 11 power reactors, is expected to be running as many as 23 by 2006, with a total generating capacity of 20GWe (48% of the nation's electricity). The Korean nuclear industry has reached a high level--certainly one of the highest in the region, but it has many difficult problems of its own. Particularly troubling are storage or management of radioactive wastes and spent nuclear fuels because reprocessing of spent fuels is not permitted by the United States, not only ROK's main supplier of nuclear fuels and equipment but also its sole guarantor of national security. This special predicament will be examined in more detail later.

Taiwan has six reactors generating about 30% (5 GWe) at present, but will build two more in the near future. A small island with geographical constraints, Taiwan has problems similar to those of Korea. Taiwan's special political position makes it even harder to solve those problems.<sup>5</sup>

China, with three power reactors now--one built in Qinshan by its own technology and two in Guangdong imported from France and the U.K.--is expanding its nuclear power program at an astonishing rate, hoping to have 16-18 reactors by 2025 with total capacity of 16 GWe. While China, an authorized nuclear weapon state, has much experience in military use of nuclear energy, it undoubtedly needs technical and financial help from abroad to realize its ambitious civilian program for the future. China also appears eager to export its home-made nuclear hardware and technology--and missiles-- in an apparent attempt to gain hard foreign currency, which is causing proliferation worries.

Finally, North Korea will acquire two LWRs (1 GWe each) sometime early in the next century if all goes well under KEDO arrangements and the Framework Accords.<sup>6</sup>

In Southeast Asia, where nuclear power has not yet been fully developed, a few countries have recently started planning the construction of nuclear power plants. Indonesia, the most advanced in that sub-region, will have its first power reactor commissioned in 2004, hoping to build 13 more reactors by 2019, generating more than 12 GWe (10% of the electricity generation). Indonesia's case will be discussed further in the following section. Thailand, reviving its 20-year old plan, is also expected to build power reactors by 2010. On the other hand, the Philippines is still interested in nuclear power generation as a means of coping with its acute electricity shortage. Malaysia and Vietnam are also pondering the possibility of introducing nuclear power into their electricity development programs in the next century. Thus it is expected that within 10-15 years, the total number of nuclear reactors operating in East Asia will be well over 120, far more than the present number of reactors running in the United States. If this trend continues, more than one-third of the world's reactors will be operating in East Asia by 2025.

## Problems Requiring Urgent Solutions

In recent years, the countries of Northeast Asia are suffering from various difficulties, largely domestic, associated with their nuclear energy activities. Let me examine some of those problems that are seriously affecting East Asian nuclear programs and seem to require urgent solutions at domestic and regional levels.



## **The Cases of Northeast Asia**

In Northeast Asia, where nuclear industry has reached a relatively high level of development, the most urgent problems are those related to the so-called "back-end" of the nuclear fuel cycle, especially low- and high-level radioactive wastes and spent fuels. These problems inevitably cause anxiety among the public, often adversely affecting further development of nuclear power programs. This is particularly true in Japan, Korea and Taiwan, as already noted.

In Korea, the situation seems quite serious. Unlike Japan, the ROK is not permitted to reprocess spent fuels, mostly of U.S. origin, even though spent fuels are accumulating in large quantity as its nuclear plants speed up operations. Korea's radioactive wastes and spent fuels, which are accumulating in the cooling ponds adjacent to the reactors or at special facilities within the plants, are expected to reach the saturation point by 2006 according to the latest estimate of the Korean Electric Power Corporation (KEPCO). Unless some drastic measures are taken, it is feared that some nuclear power plants will have to be shut down.<sup>7</sup>

In order to alleviate this situation, the Korea Atomic Energy Research Institute (KAERI) is now studying the technical possibility of burning PWR spent fuels in heavy-water reactors of the CANDU type. If this method, called "tandem recycle" or more properly "DUPIC" (direct use of PWR-fuels in CANDU reactors) proves practicable, their spent fuel problem partially may be solved. However, according to KAERI experts, there are many technical difficulties inherent in this method which seriously reduce the chance of its practical application.

Korea must find alternative means to store or otherwise dispose of their radioactive wastes either permanently, or for an interim period (usually 30-50 years pending reprocessing in the future in the case of spent fuels). But it is becoming difficult to identify extra sites for storing such wastes and spent fuels because of widespread resistance among local people. The recent plan of the Korean government to build a special storage facility on Kulop-do, a tiny island in the Yellow Sea about 110 kilometers west of Incheon, has met with violent popular opposition and was eventually canceled.

These conditions naturally increase pressure on utilities to move toward reprocessing to deal with accumulating spent fuels. However, reprocessing must take place abroad because the Korean government decided to preclude an indigenous reprocessing plant when it signed the Joint Declaration on Peninsular Denuclearization with North Korea in 1992.<sup>8</sup> They can have their spent fuels reprocessed abroad: in the U.K. (Sellafield), France (La Hague) or Russia, or even in Japan (Rokkasho, after 2005), but because most of their fuels are of U.S. origin, they must obtain the American government's consent prior to reprocessing or sending abroad their fuels. This restriction is clearly stipulated in the Korea-U.S. nuclear cooperation agreement.<sup>9</sup>

It is highly unlikely that American consent will be given to Korea as long as the political-military situation on the Korean Peninsula remains the same. However, if the situation improves significantly within 15 years, even if the two Koreas are not united, the U.S. will face strong pressure to allow Korea the right--the same right it granted Japan in the 1980s--to reprocess spent fuels at home or abroad. By 2010, Korean nuclear power generation will be large enough to economically justify reprocessing and recycling of plutonium.<sup>10</sup>

However, the U.S. still may not be able to consent to Korean reprocessing unless effective measures are devised to guard against nuclear proliferation. Thus, the necessity to establish appropriate arrangements on a regional level to ensure that peaceful uses of nuclear energy, not only in Korea but everywhere in East Asia, are carried out in strict accordance with non-proliferation requirements.

Korea also may decide to permanently forgo reprocessing for technical or economic reasons, or store waste for an interim period (30-50 years), pending reprocessing or final disposal. But Korea will still be faced with a set of difficult problems. If it cannot build enough storage facilities at home--nearly impossible-- it must find another country willing to accept its spent fuels. Even if Korea decided to ship its spent fuels to China, Russia, or the Marshall Islands, which have reportedly expressed a willingness to accept them, it would need American approval for overseas shipment.<sup>11</sup> Without an effective disposal scheme, possibly on a regional level, American approval is unlikely.

On the other hand, in Taiwan, most of the low-level radioactive wastes of the Taiwan Electric Power Company's (TEPCO) six nuclear reactors have been stored at the interim storage

facility on Lanyu (Orchid Island) about 80 kilometers south of Taitong. However, it has become impossible for TEPCO to further expand the storage capacity on the island because of objections from the local populace. In January 1997, it was made public that TEPCO had signed an agreement with North Korea in which North Korea would accept Taiwan's low-level nuclear wastes (about 60,000 drums for the first two years) for a reported \$1150 per drum. Subsequently, violent protests from South Korea and China were voiced against this arrangement.

### **The Cases of Southeast Asia**

For countries in Southeast Asia where nuclear power development has just started (Indonesia) or is about to start (Thailand), the problems are not as urgent as in Northeast Asia, but would become serious in the near future. In Indonesia, for instance, the problems are mostly related to the "front-end" of the nuclear fuel cycle: the building of basic infrastructure, technical, institutional and social, necessary for nuclear power generation. Most important is international technical assistance in nuclear safety (i.e. safe operation of reactors, control of nuclear materials, etc.), environmental management of radioactive wastes, physical protection of nuclear materials/plants, nuclear legislation, manpower training, and public education for increasing popular acceptance of nuclear energy. Some Southeast Asian countries also require special financial assistance to build nuclear power plants.

More specifically, Indonesia is believed to favor the so-called BOO (build, operate, own) formula for the first nuclear power plant scheduled to be built in Muriya in Central Java. Under this formula, the ownership of plants will, in principle, rest permanently with the foreign contractor/operator who will be responsible for the finance, operation, and maintenance of the plants. Indonesia would buy electricity directly from the foreign operator, increasing the risks for the foreign operator.<sup>12</sup>

## **Need of a New Regional Framework of Cooperation**

Technical assistance in the above-mentioned areas can be provided through existing global channels such as the IAEA or traditional bilateral channels like Japan's International Cooperation Agency (JICA). But more active and useful technical cooperation would be made possible by a new regional institution or framework in which various countries in the region, sharing common concerns, could participate and cooperate. Safety of nuclear power plants would be enhanced by regional cooperation in operators' training, information exchange, and other related programs, as illustrated in the case of the Tokyo Center of the World Association of Nuclear Operators (WANO), a private sector network of technical assistance inaugurated shortly after the Chernobyl accident.

A regional framework of cooperation would also be useful for the prevention of possible nuclear proliferation. There are of course the Nuclear Non-Proliferation Treaty (NPT) and the IAEA safeguards for this purpose, but they are not sufficient, it must be conceded, in light of past experience because the NPT lacks sanctions against violations while the IAEA safeguards do not normally apply to undeclared facilities as painfully disclosed by the cases of Iraq or North Korea. At present, the only real guarantees against proliferation, if any, lie in the sanctions based on the bilateral cooperation agreements the United States, Canada, Australia and other nuclear suppliers have concluded with several Asian countries. But there are countries within the region which have not concluded such bilateral agreements with any of the advanced nuclear suppliers.<sup>13</sup>

Let us now assume some hypothetical cases. If any country in Asia, intending to use nuclear energy for electricity, decides to conclude bilateral agreements with the United States or any other nuclear supplier from which it wants to buy nuclear reactors or fuels, there would be little problem. Nuclear transactions and technology transfers would take place in accordance with the London Guidelines established by the Nuclear Suppliers Group (NSG) for voluntary export control in 1978, shortly after an explosion in India. The United States, Canada, Australia, Japan, and Korea have joined NSG and all are committed to the application of the Guidelines in a way similar to the old COCOM.

But what would happen if a country decides to buy reactors or fuels from suppliers which do not belong to the NSG or NPT, or suppliers that would not impose sufficiently strict non-proliferation conditions on importers? What if a country should burn homemade fuels in a type of reactor which can burn un-enriched natural uranium? Can we ensure non-proliferation? Can NPT/IAEA safeguards prevent nuclear proliferation?

A system of mutual inspection, even in the form of friendly visits to nuclear facilities or "peer reviews" among regional countries concerned, can contribute to nonproliferation better than the global compulsory system such as the NPT/IAEA system. This does not imply that the IAEA does not work very effectively in East Asia, let alone in South Asia. But the IAEA, operating from Austria, far from the region, should be supplemented, if not replaced as in the case of EURATOM, by an effective regional system which better suits the regional environment. A regional system can also contribute to confidence-building and to the maintenance of peace and security within the region.<sup>14</sup>

The need for such a new regional framework has been identified with increasing keenness among nuclear policy experts. The concept of regional nuclear fuel cycle centers in general, and an "ASIATOM" concept in particular, used to be discussed informally but rather enthusiastically among Asian experts including myself during the INFCE period (1977-80) which corresponded with the latter part of the second wave.<sup>15</sup>

Today it seems that the time is getting ripe for discussing not only the concepts but also the practical strategies required to translate such concepts into reality at an early date. Recently there have been published a number of proposals for regional nuclear cooperation in Asia by the interested political leaders (such as President Fidel V. Ramos of the Philippines), experts and scholars.<sup>16</sup> However, to the best of my knowledge, none of them have gone into technical details or specifics yet.

What follows below is the "ASIATOM" proposal being developed by a group of Japanese experts and scientists in the private sector who have been working for the past few years, under my personal responsibility, with the informal cooperation of the like-minded experts of several countries within the region.<sup>17</sup> Our proposal, after some more modifications and improvements, will be published shortly in a form of a draft basic treaty establishing an "ASIATOM" for the consideration of the regional governments. For the moment, however, because of the lack of space, only the essential features of our proposal are presented.

## The Basic Concept of ASIATOM

### Purposes

The proposed "ASIATOM"--more properly called "Asia Atomic Energy Organization"--will serve *inter alia* the following purposes:

- Promote nuclear cooperation among regional countries engaged in nuclear power generation for peaceful purpose, through technical assistance, information and personnel exchange and other effective means, so that all nuclear energy activities may be carried out in a safe and secure manner;
- Help regional countries promote public acceptance of nuclear energy through appropriate regional cooperation;
- Help regional countries solve problems related to the management (including disposal, storage, reprocessing, etc.) of radioactive wastes and spent nuclear fuels, thereby contributing to the environmental protection and sustainable development of natural resources;
- Contribute to the sound development of civil nuclear energy to meet ever-increasing needs for electricity, while ensuring that NPT non-proliferation requirements are met.
- Contribute to confidence-building among regional countries and to the promotion of nuclear disarmament and the ultimate elimination of nuclear weapons.

## Membership

The ASIATOM will be open, in the initial periods, for the participation of the following countries/areas:

Australia, Canada, *China*, Indonesia, Japan, Korea, Malaysia, Philippines, Taiwan, Thailand, *United States*, and Vietnam (NPT nuclear weapon states are italicized).

Other Asia-Pacific countries that are members of APEC may also join ASIATOM when they are ready to embark on nuclear power generation and accept responsibilities under the ASIATOM treaty.

India and Pakistan may be invited to join if they accede to the NPT or otherwise agree to accept non-proliferation conditions prescribed by ASIATOM in conformity with relevant international treaties, agreements, and regulations. North Korea will be permitted as a full member of ASIATOM after its non-proliferation status is confirmed by KEDO/IAEA. It may make sense that North Korea be afforded (upon request) observer status in some of ASIATOM bodies as approved by the Executive Committee. France, Russia, and the United Kingdom, all nuclear-weapon states, may also be invited to join as observers or in any other appropriate status. Non-governmental organizations, such as electric utilities, may be permitted to join ASIATOM as corporate members, subject to the approval of the Executive Committee. Corporate members would send their representatives to technical/functional committees and relevant regional centers of ASIATOM, but they will have no right to vote.

## Organizational Setup

(a) The following bodies will be established for the decisionmaking and operation of the ASIATOM:

- General Conference (comprising the Ministerial- level representatives of all the participating member countries/areas; meeting once a year).
- Executive Committee (comprising the representatives of all the member countries/areas; meeting as frequently as necessary).
- Other functional or technical committees regarding safety of nuclear power plants, nuclear fuel cycle, training and education, non-proliferation (safeguards/inspection), etc.

(b) A small permanent secretariat will be established to perform the necessary secretarial duties of ASIATOM. The head and the deputy head of the secretariat will be appointed by the executive committee. All members of the secretariat will be accorded diplomatic privileges and immunities while performing their official duties.

## Regional Centers

The following regional centers will be established to meet the needs of ASIATOM:

- *Regional Nuclear Safety Centers*, where services for the safety of nuclear power plants will be offered, including training and education of operators of nuclear power plants, information exchange, arrangement of emergency technical assistance, etc.
- *Regional Nuclear Fuel Cycle Centers*, offering such services as the storage/management/disposal of radioactive wastes/spent nuclear fuels/surplus plutonium, reprocessing, enrichment, fuel fabrication, etc.<sup>18</sup>
- *Regional Nuclear Science and Technology Centers*, as proposed by Dr. Djaoloeis of Indonesia.<sup>19</sup>

In establishing regional centers for nuclear safety, the experience of the World Association of Nuclear Operators (WANO) can be fully utilized. The WANO Tokyo Center, which focuses on countries in the Asia- Pacific should be incorporated into the ASIATOM system. Operation of such centers is the joint responsibility of those member countries and corporate members which use the centers. Conditions and charges of services (except for those offered as ODA) will be

specified in separate documents between the parties concerned subject to the approval of the Executive Committee.

Regional nuclear fuel cycle centers may be established at appropriate sites in member countries or, in the case of interim or permanent storage/disposal of radioactive wastes or spent fuels, may also be established on appropriate islands, provided that such islands are owned, or otherwise controlled by, an ASIATOM member; or provided that such islands are made available for the use of ASIATOM under special arrangements.

It is highly pertinent to remember that during the INFCE period (1977-80), the United States and the Carter administration proposed to Japan to conduct a joint feasibility study of an international spent fuel storage facility to be constructed on an atoll called Palmyra, approximately 2000 kilometers south of Hawaii, which was under the administrative control of the U.S. Department of Interior at the time. The joint study, basically for non-proliferation purposes, was carried out intensively for two years by experts of both countries, but was suddenly discontinued when President Ronald Reagan replaced Carter in early 1981. A similar study on international spent fuel management (ISFM) was carried out by an intergovernmental committee under the auspices of IAEA in parallel with the INFCE during the same period. It was also discontinued shortly after the INFCE's completion in 1980. From the perspective of a Japanese delegate who participated in these studies, it is a great pity that the results of these studies have been totally forgotten ever since. These studies could be utilized in an "ASIATOM" exercise.<sup>20</sup>

Clearly, the storage and management of spent nuclear fuels is one of the most urgent problems regarding civilian use of nuclear power in Asia. Therefore, as a preliminary step towards a solution, it is highly prudent to undertake international studies on various technical options by nuclear engineers in the region, as proposed by noted Japanese scholar Suzuki Atsuyuki in this volume.

The more sensitive problems of reprocessing of spent fuels, enrichment of uranium beyond 20% and permanent or interim storage of surplus plutonium can take place only with the consent of the original suppliers and under effective safeguards/inspection by the IAEA (irrespective of the status under NPT). It is assumed that the consent of the original suppliers will be given readily under ASIATOM.

Operation of regional fuel cycle centers is the joint responsibility of those member countries and corporate members (such as utilities) which use such centers. The conditions and charges of services offered by the centers will be specified in separate documents between the parties concerned subject to the approval of the ASIATOM Executive Committee.

### **Regional Safeguards/Inspection System**

To ensure that non-proliferation requirements are fully met, it would be highly desirable that ASIATOM administer regional safeguards/inspection of civilian nuclear programs on its own, without distinction between nuclear-weapon states and non-nuclear-weapon states.

Because of the political difficulty inherent in such a system, I expect ASIATOM's functions vis-à-vis nuclear-weapon states will, in the initial period, be performed in the form of "peer reviews" by ASIATOM inspectors based on voluntary acceptance of such states.

On the other hand, ASIATOM functions vis-à-vis non-nuclear-weapon states will be performed in such a manner as to supplement the IAEA safeguards in accordance with the relevant agreements between the countries concerned and the IAEA.

For this purpose, the ASIATOM will have an appropriate number of technical experts permanently attached to it who will visit nuclear plants and other facilities of the member countries as frequently as necessary. ASIATOM inspectors will be appointed from among the nationals of member countries. They will be accorded diplomatic privileges and immunities while performing their official duties.

Further details of the ASIATOM regional safeguards/inspection system can be spelled out at a later stage, when sufficient experience has been accumulated within an ASIATOM framework.

## Miscellaneous Items

The expenses related to the operation of ASIATOM will be borne by its members countries (and corporate members) according to a scale of assessment adopted by the Executive Committee on the basis of GNP, the total capacity of nuclear generation, etc. The scale of assessment will be reviewed and renewed every five years.

ASIATOM will maintain close relationships with the IAEA and other international or regional organizations whose activities are relevant and its activities will be reported annually to the Board of Governors of the IAEA.

The basic treaty establishing ASIATOM will become effective when more than five countries ratify it. After entry into force, the treaty may be amended with the concurrence of more than two-thirds of the member countries. Any member may withdraw from the ASIATOM when its supreme national interest is endangered in an emergency situation. Any member persistently violating its obligations under the treaty may be expelled from ASIATOM by the decision of the Executive Committee. However, the withdrawal or expulsion of any member will not become effective while its nuclear fuels or wastes are in the process of services at any ASIATOM regional fuel cycle centers.

## Strategies for Implementation

ASIATOM as roughly envisaged above will not be accomplished easily in the near future for a number of political and technical reasons. It is to be emphasized, therefore, that a pragmatic and progressive approach should be adopted for the realization of the concept. The executive and administrative bodies, functional centers and facilities or any other components of ASIATOM as suggested above need not be established fully at the same time as its inauguration. They can be developed in a mosaic fashion, progressively over the period of five to 10 years, according to priority based on members' needs and feasibility.

This is precisely where the proposed ASIATOM will differ from EURATOM which was created in a quite systematic way shortly after World War II under vigorous American initiative.<sup>21</sup> Such a strong initiative can hardly be expected to come from the United States, where nuclear energy has lost the momentum it held until a few decades ago. Despite resemblance in the naming, there will be little similarity between the EURATOM and the proposed ASIATOM. Likewise, albeit the ASIATOM may look analogous to other regional denuclearization/safeguards systems such as the Tlatelolco, Rarotonga, and the recently signed Southeast Asia Nuclear Weapon-Free Zone (NWFZ) Treaties, it will be very different from any of them in many important respects.

This difference is inevitable because within Asia, unlike other regions, there are nuclear-weapons states (China, the U.S. and Russia) which are granted special status under the NPT regime and pose complicated problems in creating a regional organization like ASIATOM. There are also other challenging difficulties, such as wide gaps among the regional countries in the level and size of their respective civilian nuclear energy programs. These and other differences will necessitate a different approach for Asia.

In recent years, Asia has successfully developed multilateralism in its unique way--the so-called "Asian Way"--through the experiences of ASEAN, PECC, APEC and the ASEAN Regional Forum (ARF). The proposed ASIATOM will be another good example of this "Asian Way."

Although ASIATOM can only be realized over a long period of time, first steps need to be taken soon since an increasing number of Asian countries are committed to nuclear energy for electricity. Therefore, some country or countries within the region must take such an initiative urgently. The United States is not in a position to do so, but is Japan, the second most advanced in civil nuclear program in the region, able to show initiative? Unfortunately not, in my view, because of the political environment surrounding Japan which is a remnant of the not fully liquidated legacy of its past.

Despite this, Japan is making useful contributions in this field. One of Japan's first and most important contributions was the promotion of the Regional Cooperative Agreement (RCA)

for Nuclear Science and Technology in Asia in cooperation with IAEA and interested regional countries.

Since then, under the umbrella of this regional agreement, various useful activities are being carried out with Japanese initiative or support. For example, the Japan Atomic Energy Commission has been sponsoring an annual International Conference on Nuclear Cooperation in Asia in Tokyo since 1990, to which ministerial delegates are invited from all the Asian countries committed to nuclear energy, including Australia (the United States, Canada, India, and Pakistan are invited as observers). A variety of cooperative projects in areas of mutual concern, such as the operation of research reactors, safety of nuclear power plants, and public acceptance of nuclear energy, are being carried out within the framework of this regional conference. Another international conference on nuclear safety was held in Tokyo in November 1996 on Prime Minister Hashimoto's initiative.

In the private sector, the Japan Atomic Industrial Forum (JAIF), an active association of utilities, manufacturers or other firms related to nuclear energy, is holding an annual conference with one or two sessions always devoted to regional nuclear cooperation. Moreover, the JAIF has been sending annually a technical mission to several Asian countries for more than 10 years, encouraging information exchange. Many technical training courses or seminars are being organized at Japanese nuclear research institutes or universities for Asian experts funded by the government's ODA.

Nevertheless, Japan must not place too prominent a role for nuclear cooperation in Asia lest it should incur any distrust among fellow Asians who doubt Japan's nuclear program, especially plutonium program, or from Americans and Europeans who suspect that ASIATOM might be a camouflage for Japanese attempts to monopolize the Asian nuclear market. When I explain ASIATOM proposals in the United States or Europe, I hear complaints that they are akin to a nuclear remake of "The Greater East Asian Coprosperity Sphere." While nothing could be further from the truth, Japan is well advised to be as modest and discrete as possible.

A new constructive initiative must come from another country or a group of countries other than the United States and Japan such as Korea, Indonesia, the Philippines, or Thailand. In this respect, it is encouraging that Philippine President Fidel Ramos recently expressed positive interest in the ASIATOM idea when he spoke at an international conference on the "Future of Asia" in Tokyo in May 1996, he stated:

We are encouraged by the results of last month's nuclear summit in Moscow. That summit reflected the serious commitment of the participants to cooperate in coming to grips with the issues. But Chernobyl is still very much alive in our memories.

Before too long, East Asia may have to convene its own regional nuclear conference to establish the framework for management cooperation in this sensitive area.

Such a framework should be consistent with IAEA guidelines, and it should be open to practical participation by countries from outside the region who possess nuclear power. And it should also be an instrument for containing any form of nuclear proliferation in the region and as a supplement to ASEAN's Southeast Asian Nuclear Weapons Free Zone Treaty.

That framework should be developed and guided by region-wide consultations. Nuclear safety is a trans-regional concern; it should not be left only to countries having nuclear power. We should also consider any special nuclear needs of the region's developing nations.

Just as worthy of study is the development of a possible "ASIATOM" (cooperation among Asian countries for containing nuclear proliferation, similar to EURATOM), which involves mutual safeguards by member countries. This scheme should involve essentially the two Koreas, China, Taiwan, Japan, the United States, Russia, Canada, New Zealand, and the ASEAN states.

Consideration should be given to the possibility of international enrichment plants, reprocessing plants, and international plutonium storage.

This agenda for political cooperation, if tackled by our countries in a spirit of give and take, should yield a consensus that will foster peace and stability in Asia. But, even more than peace and stability, it will help spread the economic miracle to every part of the Asian continent--which is the goal we all want.

The Filipino support of ASIATOM was reiterated by Foreign Secretary Domingo L. Siazon, Jr. when he spoke in Tokyo in May 1997 at the same international conference President Ramos had addressed the year before.<sup>22</sup> Siazon stated:

Promoting nuclear safety is another issue. At this forum last year, President Ramos called for the formation of an "ASIATOM" for this purpose. The recent accident in Tokai makes the President's call chillingly prescient. If accidents like this can occur in Japan, our region's most technologically advanced nation, what could happen in other countries?

Should regional public opinion turn decisively against nuclear energy, this would limit our ability to exploit the nuclear option to fuel our continued growth. Foreclosing the nuclear option could intensify our region's growing dependence on oil and gas imports. East Asian oil imports are projected to rise over time. China, a major regional oil producer, is already a net oil importer. Dependence on imports may also exacerbate rivalry over the region's offshore hydrocarbon fuel resources, large concentrations of which are believed to exist in the South China Sea.

We must improve regional cooperation on new problems that pose dangers to the integrity, safety, and stability of our societies.

The best strategy would be for an appropriate proposal for ASIATOM to be made within APEC, to which all these countries belong, then the United States and Japan, as well as Canada, Australia and even China, would be able to support the proposal and provide necessary technical and financial backup.<sup>23</sup>

Finally, if nuclear energy is to have a genuine renaissance and continue to survive in Asia beyond the turn of the century, the governments must communicate the political will to create something like ASIATOM. Asia's future peace and prosperity depends on the long-term security of energy supply, which must include the long-term stability of peaceful use of nuclear energy. In this sense one can regard ASIATOM as a viable collective security system for Asia.

## *Endnotes*

1. Unless otherwise noted, most of the long-term projections in this paper are based directly or indirectly on the "Nuclear Power Outlook in Northeast Asia" presented by Dan Nikodem of the Energy Information Administration, U.S. Department of Energy, at the Northeast Asia Cooperation Dialogue V, Energy Workshop, in Seoul September 11-12, 1996.
2. These figures were given to me during the private conversations I had with senior officials of the Philippines government in Manila in the early 1980s.
3. It is to be noted that the research reactor "CIRUS" in the Bhabha Atomic Research Center in Bombay with which the Indians produced the plutonium used for the 1974 explosion had been exported from Canada while the heavy water used in that reactor had been exported from the United States.



4. Japanese Environment Agency, *Annual Report on Japan's Environment-1996*, June 1997, pp. 62-63.
5. Most of the low-level radioactive wastes of the Taiwan Electric Power Company's six nuclear power plants have been stored at the interim storage facility on Lanyu (Orchid Island) about 80 km south of Taitong. However, it has become impossible for TEPCO to further expand the storage capacity on the island because of the objection of the islanders. Recently in January 1997, it was announced that TEPCO signed an agreement with North Korea whereby the latter will accept the former's nuclear wastes--about 60,000 barrels for the first two years. It is reported that TEPCO will pay \$1,150 per barrel to North Korea. Subsequently, violent protests are being voiced in South Korea against this arrangement.
6. It is noted in this respect that the situation of China (PRC) and North Korea, with their unique socio-political structure and policy-making mechanism, seems to differ significantly from the rest of East Asia. The lack of transparency and information about these two countries, particularly the latter, is another constraint for judging their real situation.
7. According to a recent KEPCO estimate, their storage capacity is likely to be expanded to meet demand until 2016 because of technological improvements.
8. There are sharp criticisms about this Joint Declaration in some circles in South Korea. It is repeatedly argued that South Korea should not have forsworn reprocessing in the first place. See Taewoo Kim, "Japanese Ambitions, U.S. Constraints, and South Korea's Nuclear Future," in *Japan's Nuclear Future: The Plutonium Debate and East Asian Security*, edited by Selig S. Harrison, Carnegie Endowment for International Peace, 1996, pp. 102-105.
9. Under the old Japan-US agreement, Japan had to obtain an American approval, legally called the "joint determination" that a particular reprocessing could take place in such a way as to be effectively safeguardable every time Japan wanted to reprocess a specific amount of spent fuel. This case-by-case approval system was criticized by the Japanese side as seriously lacking predictability and therefore detrimental to the stability of Japanese nuclear programs; it was replaced with a long-term generic approval system by the new bilateral agreement which became effective in 1988.
10. It is recalled that during the International Nuclear Fuel Cycle Evaluation (INFCE) in 1977-80, Japan defended its reprocessing policy on the grounds that there would be enough economic justification for reprocessing spent fuels and recycling the separate plutonium when the total generating capacity of nuclear power plants had reached 20GWe or more. Japan's nuclear industry reached that size in the late 1970's.
11. In a similar situation, Taiwan has recently signed an agreement with North Korea in January 1997. See note 5 above.
12. In March 1997, Minister of Research and Technology, Dr. Habibie, stated that the Muriya project might well be delayed for another 10 or 20 years, adding that nuclear power would be "our last option."
13. For that matter, Japan has never concluded bilateral nuclear cooperation agreements with any developing countries with the sole exception of China, with which Japan concluded an agreement in 1986 just before the export of a Mitsubishi-made pressure vessel for the *Qinshan No. 1*. The absence of the bilateral cooperation agreement with any Southeast Asian country has long been regarded as reflecting the negative attitude of the Japanese government towards nuclear cooperation with developing countries.
14. The international security aspects of the "ASIATOM" proposal are discussed in some detail in my article "Japan Needs No Umbrella," *The Bulletin of the Atomic Scientists*, March-April 1996 pp. 46-51.
15. The Summary Report of the International Nuclear Fuel Cycle Evaluation (INFCE), published by the International Atomic Energy Agency, February 1980.
16. Included among the various proposals so far made are those by Fidel V. Ramos, President of the Philippines, presented in his keynote address "Asia: A Tradition of Confidence and Consensus Building" at the International Conference on the Future of Asia sponsored by the Nippon Keizai Shimbun, May 17, 1996; Richard Armitage, former Assistant Secretary of Defense, in his article "The modernization of the U.S.-Japan Security Relationship," *Gaiko Forum*, June 1996, pp. 53-54; Kent E. Calder, "Pacific Defense: Arms, Energy and America's Future in Asia," Leighco, Inc., 1996; Calder, "Asia's Empty Tank," *Foreign Affairs*, Spring 1996. More detailed

proposals by nuclear engineers are found in Jor-Shan Choi's paper "An East Asia Regional Compact for the Peaceful use of Nuclear Energy;" Atsuyuki Suzuki's paper "A Proposal for Regional Spent Fuel Storage;" and Tatsujiro Suzuki's paper "Lessons from EURATOM for Possible Regional Cooperation in the Asia-Pacific Region;" all presented at the Energy Workshop of the Northeast Asia Cooperation Dialogue V, Seoul, September 11-12, 1996. My latest proposal is contained in the Interim Report of the Study of the Japan Council on Nuclear Energy and Disarmament (CNED) on "ASIATOM," published in June 1995.

17. Interim Report of the CNED Study on "ASIATOM," *op cit*.

18. Clearly one of the most urgent problems in Asia is the storage and management of spent nuclear fuels. As a preliminary step towards the solution of this problem, it seems wise to undertake international feasibility studies on various technical options by nuclear engineers in the region, as proposed by Atsuyuki Suzuki in his paper cited above.

19. Dr. A. Djaloeis, "Asiatom?: A View From the Indonesian Perspective," in *Whither "Atoms for Peace" in Asia?*, Kumao Kaneko, ed., Tokyo, September 1997, pp. 57-68.

20. The results of the "Palmyra Project" are contained in the Executive Summary and the Final Report of the "Pacific Basin Joint Feasibility Study" prepared jointly by Japanese and U.S. study teams, December 1982. Technically, these reports are still considered to be confidential.

21. For the history of the EURATOM, see Tatsujiro Suzuki's paper cited in note 16 above.

22. Domingo L. Siazon, Jr., speech at the "International Conference on the Future of Asia," sponsored by the Nikkei Shimbun. The texts of the speeches of President Ramos and Foreign Secretary Siazon are available at the Embassy of the Philippines in Tokyo.

23. One advantage of APEC is that Taiwan, well established in civil nuclear programs, participates in APEC as a formal member under the name of "Taipei, China."

# A Proposal for Regional Spent Fuel Storage

by *Atsuyuki Suzuki*

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To allay international fears of nuclear weapons proliferation by either nations or terrorists, an international safeguard system is inevitably required for managing spent nuclear fuel and post-reprocessing separated plutonium, which can be used in manufacturing weapons. Experts advise that nuclear waste should be disposed of in deep underground repositories, to isolate it from the biosphere for the thousands of years required before radioactive decay renders it harmless. Many countries understand deep underground storage to be safe and feasible; most of the required technologies are already available. However, any permanent storage scheme seems inevitably to encounter the NIMBY (not in my backyard) syndrome.

An intermediate storage facility could delay countries' decisions for permanent underground storage until NIMBY issues have been ameliorated and proliferation concerns resolved. However, such a repository would be highly capital-intensive, and most producers of spent nuclear fuel have nuclear programs too small to justify the cost. There is also a danger that "intermediate" facilities could become permanent by default.

I propose an East Asian regime to build and operate a facility for intermediate storage of spent fuel from regional nuclear power plants, called the East Asian Collaboration for Intermediate Storage (EACIS). The facility would be devoted only to intermediate storage of civilian spent fuel, not to its final storage, nor to military-related fuel storage. The latter measure would facilitate collaboration among weapons- and non-weapons states.

To prevent indefinite "storage-creep," the storage period would be fixed in advance by a prescribed formula. That is, the minimum and maximum storage time would be designated; and following the minimum number of years (say, 30), participating countries would decide whether to extend the time and, if so, for how long--up to the maximum (say, 50 years).

Obviously, the host country would need large economic and technological incentives. To this end, all participants in the collaboration would be subject to an incentive/tax system in which each is obliged to look for a final geological repository within the minimum length of intermediate storage time.

This part of the regime would provide for construction and operation of an international facility for research on underground geological nuclear waste disposal, called the East Asian Collaboration for Underground Research (EACUR). During the intermediate storage period, the EACUR facility would be devoted to research and development of geological disposal technologies. One of its most effective features would be public education, by demonstrating the safety and technical feasibility of geological disposal, in order to overcome NIMBY resistance.

In East Asia, there are only a few countries now operating nuclear power stations, but many other countries are interested in doing so. Anti-nuclear environmentalists are likely to see international collaboration as a way of both prolonging and expanding nuclear power use, and therefore oppose it. It must be emphasized to the concerned populations that spent fuel is already with us--storage is necessary irrespective of whether or not nuclear power usage expands to new countries. Medical and scientific research also generate a variety of radioactive waste. That material must be safely managed and stored as well.

The economies of scale inherent in cost-sharing would add flexibility to present East Asian national nuclear energy programs. Without collaboration, spent fuel will most likely remain on-site at nuclear power plants--currently the cheapest option. And at on-site storage, in the absence of international safeguards, spent fuel poses not only a local safety hazard, but spawns weapons proliferation fears--suspicions about North Korea's nuclear program arose because of a lack of transparency regarding its nuclear program. But if additional plants are added to existing international safeguard regimes (IAEA), the burden of inspecting such widely dispersed facilities could overwhelm IAEA budgets.

To realize this proposal, close collaboration among East Asian governments is of course essential, but just as important is commercial collaboration among electric utilities, who in principle should and could share associated costs. Vital is the identification of potential

participants and a focus on financial commitments and economic issues. The Tokyo chapter of the World Association of Nuclear Operators, or a similar agency, could serve as organizer.

Equally important is approval by nuclear suppliers, who are responsible for guaranteeing that exported nuclear technologies and fuels are used only for peaceful purposes. This is especially true in the case of the United States, with its so-called "contamination principle," which means that not only nuclear fuels originating there, but also any fuels mixed with U.S.-supplied fuels, remain subject to U.S. legislation.

I believe that Japan is ready to participate in such a regime, even though Japanese legislation currently allows only for expansion of on-site storage. Both Japanese utilities and the Japanese public will see that this proposal adds flexibility and international harmony to Japan's existing nuclear power program.

# A Regional Compact for the Peaceful Use of Nuclear Energy in East Asia

*by Jor-shan Choi*

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Nuclear power cannot be a major energy source in the world's energy economy unless the problem of spent fuel management and radioactive waste disposal is resolved; international fears of nuclear weapons proliferation, a great impediment to nuclear-energy use in developing countries, are mitigated; the costs of nuclear energy production are lowered; and unfavorable public perception of reactor safety, inflamed by the Three Mile Island (TMI) mishap and the Chernobyl disaster, is overcome.

Given the global trend toward more regional economic development, group security arrangements, and collaborations on safety issues transcending national boundaries, a possible solution to these problems in East Asia is the formation of a regional nuclear energy compact for nuclear cooperation. Such a compact could resolve East Asian nuclear-proliferation and waste-management concerns through effective spent fuel and special nuclear material (SNM) accounting, management, and final disposition. It could establish appropriate nuclear power plant operation safety cultures to allay public fears, and could also promote regional economic cooperation supported by a reliable, cost effective and environmentally sound nuclear energy supply.

Nuclear energy, once deemed as a cheap, abundant and environmentally benign energy source, has been plagued by:

- problems associated with management and disposal of spent fuel and radioactive wastes;
- concerns over global proliferation and safeguards and security of separated nuclear materials;
- adverse public perception of nuclear safety of operating plants, especially after the TMI incident and the Chernobyl accident, and most recently, over the long-term disposal of radioactive wastes; and
- steep competition for electricity generation from other fuel sources, especially, in countries with deregulated (or privatized) utility industries.

**Radioactive Waste Management**--The generation of nuclear energy in light water reactors (LWRs) using low-enriched uranium (LEU) as fuel produces spent fuel which contains plutonium as a by-product. The spent nuclear fuel would be stored in cooling water pools at reactor sites and eventually destined for final disposal in a geologic repository. However, there are an increasing number of utilities in many nuclear power countries whose spent fuel inventory will exceed their storage capacity before a geologic repository is available. These utilities must expand interim storage capabilities for spent fuel or face premature shutdown of their reactors. Dry storage of the spent fuel is an option, but the storage casks are usually stored above ground and at reactor sites, visible from local communities and raising anxiety among the local populace.

The spent nuclear fuel could be reprocessed using a conventional aqueous process, a method adopted by many nuclear power countries, including France, England, Japan, and Russia. Spent fuel reprocessing would separate uranium and plutonium from other highly radioactive materials in the spent fuel. The separated uranium could be re-enriched and fabricated into UO<sub>2</sub> fuel for recycling. The separated plutonium could be mixed with natural uranium (or depleted uranium) and fabricated as MOx fuel and recycled into the reactor to produce nuclear energy. The remaining radioactive materials would be vitrified, most likely into borosilicate glass, and eventually also destined for final disposal in a geologic repository.

In addition to spent nuclear fuel from commercial power producing reactors, many countries possess spent fuel produced from other types of reactors, such as research, weapons-production, and naval reactors. The nature of radioactive disposal can be different for different back end fuel cycle policies adopted by these countries. However, the political difficulties of siting

waste repositories are the same and are formidable in countries with dense population and small geographical area, such as Japan.

**Nuclear Nonproliferation**--Separated plutonium, deemed "nuclear weapons usable," also can become a target of nuclear proliferation. The United States is very concerned about what to do with separated fissile materials (Pu-239, and U-235) from dismantled weapons and from fuel-reprocessing facilities; specifically the potential for theft and diversion of these materials in countries where appropriate material control and accountability systems do not exist. The world is awash in separated fissile materials, especially weapons-usable plutonium. There are hundreds of tons of plutonium in deployed weapons, in weapons marked for dismantling, in scrap at the nuclear weapons production complexes, and in stockpiles at fuel-reprocessing plants. Every year, the 440 commercial power reactors scattered among 30 countries produce 6,000-7,000 tons of spent nuclear fuels containing 60-70 tons of plutonium.

The management and disposal of spent nuclear fuel produced by nuclear reactors (civilian, research, production, and naval) and the separated fissile material (Pu- 239 and U-235) from dismantled nuclear weapons and reprocessed spent fuel are currently among the most pressing environmental and proliferation problems. Solutions to the nuclear waste management problems, together with answers to nuclear proliferation concerns, are urgently needed.

**Nuclear Safety**--Public confidence in nuclear power has greatly diminished since the accidents at TMI and Chernobyl. The partial core meltdown in the Unit 2 reactor at TMI in 1979 did not cause any human casualties, but the incident brought in numerous safety fixes and excessive regulations, resulting in delay of plant construction and significant cost increases. Chernobyl demonstrated that major nuclear accidents have a far more widespread effect than accidents with any other source of energy production. It also provided proof of the transnational nature of nuclear safety. To date, the Chernobyl accident almost bankrupts the energy economy in Ukraine and continues to cast a long safety shadow over the nuclear industry worldwide.

Concern for nuclear safety also affected technologically advanced Japan. In December 1995, a sodium leak in the secondary loop of the 280 MWe Monju fast breeder reactor (FBR) prompted a shutdown. The leak was caused by a broken thermowell and about 700 kg of non-radioactive sodium was lost. The Power Reactor and Nuclear Fuel Development Co (PNC) admitted a failure in its command structure at the time of the leak, and the deputy general manager investigating the incident committed suicide. The incident shook the foundation of public trust in the government on nuclear matters and resulted in several local communities' opposition to construction of new nuclear plants.

**Economic Competitiveness**--Public debate and skepticism about nuclear safety and the long-term disposal of radioactive wastes have undermined the credibility of many nuclear power industries. Some of these industries (in the U.S. and England), in the midst of adjusting to the deregulation and privatization in their respective economies, face heavy competition for electricity generation from other fuel sources.

A recent study, commissioned by the Interstate Natural Gas Association of America Foundation, reported that 37 nuclear power plants representing 40% of the United States' nuclear generating capacity might be forced to close prematurely, driven out of business by over-market production costs. Most of the power reactors in the United States were custom built, making the costs of operation and maintenance of these plants very expensive. Fortunately, this is not the norm for other nuclear power countries. France and South Korea, for example, have standardized their plants, and Japan has worked diligently to keep its nuclear operating and maintenance costs low to maintain a competitive edge relative to fossil fuel plants. Not all countries have wide access to other cheap fuel sources for electricity generation like the United States and their reliance on nuclear for electricity generation is evident. However, increasing competition and deregulation in the electric power industries in several of these countries will apply financial pressure on the utilities and make investments for new nuclear plant construction--or continued operation of existing non-economic plants--harder to justify.

Given the trend towards regional economic development, multilateral security arrangements, and collaborations on nuclear issues transcending national boundaries, a possible solution to these nuclear problems is the formation of a regional compact for the peaceful use of nuclear energy.<sup>1</sup> Such a compact, as proposed here, could resolve waste-management and nuclear-proliferation concerns through regionally-coordinated spent fuel and SNM accounting,

management, and final disposition. It could establish appropriate regional safety cultures for operating nuclear facilities to allay public fears, and could also promote regional economic cooperation supported by a reliable, cost-effective, and environmentally-sound nuclear energy supply.

The regional compact concept for the peaceful use of nuclear energy is examined for East Asia, comprising China, Japan, North and South Korea, Taiwan, and the Russian Far East. The compact would cover declared nuclear weapons states (China and Russia) and a potential nuclear rogue country (North Korea). It also would contain fast-growing and energy-dependent economies (China, Japan, South Korea and Taiwan) and sizable and ambitious nuclear energy programs (Japan and South Korea). The nuclear programs of these states are outlined in Table 1.

Countries in East Asia share close proximity and common needs for stable and reliable energy supplies, radioactive waste disposal, reactor safety, and regulatory standards. They also share territorial disputes, overlapping security interests, concurrent interdependency and competition in regional economic expansion, and historically-rooted mutual distrust of expansionist aims.

The main thrust of this study is to consider the feasibility of establishing such a compact. It examines the need for an East Asian regional compact framework, identifies mutual interest and common ground for this diverse group of countries, and suggests a modest approach for pursuing a regional framework for nuclear cooperation in East Asia.

The need for an East Asian Regional Compact Framework is examined based upon the criteria of energy, environment, security, safety, domestic policy and politics, and economics. Discussions include the search for answers to questions such as, "Is now the time to establish a nuclear cooperative framework in East Asia?" and "What kind of regional framework should be made for East Asia?" I also explore the role which the United States would play in such a compact, if the U.S. is at all interested in participating in such a multilateral framework. It argues that the current *status quo* for regional nuclear issues--significantly molded by U.S. bilateral treaties--is problematic, and suggests that a multilateral compact approach could be a viable alternative. This includes summaries of present and planned nuclear programs in China, Japan, South Korea, North Korea, Taiwan, and the Russian Far East. This is followed by a pros-and-cons analysis of the nuclear compact for each country in East Asia.

Finally, a proposal for how to pursue a regional framework for nuclear cooperation in East Asia is presented, including suggested activities essential to the objectives and the formation of an East Asian regional compact. This includes my thoughts regarding the need for further studies in this area.

Impacts of the East Asian regional compact on specific regional nuclear issues are included in the appendices, including:

- (1) The U.S. nuclear export controls to China,
- (2) Peaceful use of plutonium in Japan,
- (3) South Korean's research on DUPIC,
- (4) Taiwan's security concerns and spent fuel management problem,
- (5) The U.S. - DPRK Agreed Framework,
- (6) Russian's nuclear wastes in the Far East,
- (7) Uranium enrichment and the front end nuclear fuel cycle policies,
- (8) Spent fuel management programs and back end nuclear fuel cycle policies.

## A Regional Compact Approach for the Nuclear World

Nuclear energy, currently supplying 17% of worldwide electricity demand, cannot be expanded into a major supply source unless the radioactive waste problem is resolved. In addition, a more proliferation-resistant nuclear system is essential, and nuclear energy-generating facilities must be designed and operated with more passive-safety systems and at less cost to make nuclear energy more viable.

Radioactive wastes from nuclear reactors pose long-term health risks and because of their longevity, must be properly managed to ensure prolonged isolation from the biological environment. Many countries with advanced nuclear energy programs are exploring the possibility of permanent waste disposal in underground geological repositories. However, the political difficulties of siting such waste repositories are immense, especially in countries with small geographical areas.

Proliferation resistance in the nuclear fuel cycle is an essential element in reducing the risks to society associated with possible theft or diversion of fissionable nuclear materials. However, since it is not feasible to prevent the atom used for peaceful means from being used militarily, a proliferation-resistant fuel cycle requires political agreements supplemented by regional/ international safeguards and inspection.

Regarding safe operation of nuclear facilities, the events at TMI and Chernobyl indicate that radiation fallout can transcend national borders, endangering neighboring countries. The overhaul of the U.S. regulatory system following the TMI incident resulted in significant increases in the capital requirements and operating costs of nuclear power plants. And the Chernobyl accident still casts a long shadow of public concerns about the safety of nuclear power operation, especially for reactors designed and operated in Eastern Europe.

In the post-Cold War era, when economic development and rising standard of living command higher priorities, a stable and reliable energy supply is essential for regional and global economic development. A regional compact for the peaceful use of nuclear energy is an essential part of sustainable global energy development.

Major elements of this framework would include:

- **A regional area of concern**--a group of countries already formed into a regional economic block, such as NAFTA, EU, ASEAN, etc.;
- **A host country** whose obligation is to receive spent fuel and/or radioactive wastes from other regional countries and provide a means of disposing the region's nuclear wastes. Economic compensation to the host country would be paid by other regional countries. If a reprocessing fuel cycle is the intended nuclear policy, the host country must be a declared nuclear weapons state, otherwise regional countries should support a direct-disposal fuel cycle with the host country operating a regional spent fuel repository;<sup>2</sup>
- **Member countries** operate their nuclear facilities for peaceful purposes. Spent fuel would be shipped to and fresh fuel would be shipped from the fuel cycle center(s) in the host country. If a member country already has fuel cycle facilities and capabilities, the regional countries (including the host country) should establish and maintain a group of technical personnel for safeguards and inspection of these facilities to ensure transparency of intent and secure separated nuclear materials; and
- **IAEA** must provide safeguards and security inspection to regional fuel cycle centers and promote the use of internationally accepted safety standards and requirements for the safe operations of nuclear facilities.

The focus of this study is on an East Asian regional compact. This is the most dynamic region in the world today for nuclear energy development, consisting of declared nuclear weapons states (China and Russia) and several sizable and ambitious nuclear energy programs (Japan and South Korea). Countries in the region face common problems: regional economic expansion and competition, the need for stable and reliable energy supply, radioactive waste disposal, reactor safety and regulatory standards, mutual security interests, but must overcome mistrust of each other's expansive ambitions because of historical factors.

The objectives of the East Asian regional compact framework are:

- **Economic Cooperation**--The regional compact framework would promote regional economic cooperation in Asia by providing a stable, affordable, and environmentally-accepted source of energy essential for economic development.
- **Proliferation Resistance**--The regional compact framework would establish a regional nuclear material control regime to control the production of SNM and provide monitoring



- by regional personnel. This regional nuclear material control regime would be supplemented and supported by IAEA's safeguards and security systems.
- **Radioactive Waste Disposal**--The regional compact framework would provide regional spent fuel storage facilities and a waste repository for all radioactive waste generated in the region. The host country should be selected based on the availability of suitable sites, proximity to member states, and should be compensated (by financial means) for providing this waste storage and disposal service.
  - **Nuclear Safety**--The regional compact framework would promote, implement, and standardize a regional safety culture for operating nuclear facilities, including the development of prudent safety practices, regulation of regional nuclear facilities with internationally accepted safety standards and requirements, training of operational personnel, and coordination for regional nuclear emergency response.

## The Need for an East Asian Regional Compact Framework

### Background

In the last two years, there were considerable discussions about the possibility of creating an Asian regional nuclear cooperative framework.<sup>3</sup> Atsuyuki Suzuki of Tokyo University first proposed an "Asian equivalent of EURATOM," in that all regional nuclear programs, including Japan's plutonium use, would be made more transparent to the international community. As a member of the Joint U.S.-Japan Study Group on Arms Control and Non-Proliferation After the Cold War (ACNPACW), he recommended that East Asian countries explore cooperative arrangements leading to the creation of an Asian Atomic Energy Community (ASIATOM) that would promote transparency, the safe operation of nuclear facilities, and the safe disposal of nuclear waste. In September 1996, he also proposed two mechanisms for East Asian collaboration that are described in Suzuki's chapter in this volume: (1) construction and operation of an international facility for immediate storage of spent fuel produced in East Asia, named the East Asian Collaboration for Intermediate Storage (EACIS); and (2) construction of an international facility for research on geologic disposal, the East Asian Collaboration for Underground Research (EACUR).

Brad Roberts and Zachary Davis of the U.S. committee of the Council for Security and Cooperation in Asia and the Pacific (CSCAP) proposed nuclear cooperation in the Asia-Pacific to establish regional arrangements for energy and safety cooperation, regional safeguards, nuclear research cooperation, and frameworks for the management of the front end and back end of the nuclear fuel cycles.<sup>4</sup> Robert Manning, also a member of U.S.-CSCAP, proposed the creation of a "PACATOM" organization to deal with Japan's existing stock of excess plutonium and the proliferation concerns associated with the plutonium stock.<sup>5</sup> Hiroyoshi Kurihara of the Tokyo Nuclear Material Control Center, concerned that the name ASIATOM may imply the inclusion of only Asian countries, suggested a PACATOM to include the U.S., Canada, and Australia.<sup>6</sup> Ryukichi Imai, a former ambassador in Japan's foreign ministry, proposed a cooperative regional approach to the front end of the fuel cycle, including construction of joint facilities for uranium enrichment and plutonium use and standards on safeguards control and safety.<sup>7</sup> As explained in his chapter in this volume, Kumao Kaneko, president of the Council on Nuclear Disarmament and Non-Proliferation, with the endorsement of Japan Atomic Industrial Forum (JAIF), proposed the creation of an Asia-Pacific Organization for the Peaceful Use of Nuclear Energy (APOPUNE). It is more conveniently called ASIATOM to promote technical cooperation and public acceptance of nuclear power generation and to solve both front end and back end problems of the nuclear fuel cycle. Proposed initial membership would include Australia, Canada, China, Indonesia, Japan, Malaysia, Philippines, South Korea, Taiwan, Thailand, the United States, and Vietnam. Other countries would join later. And finally, William Dircks, head of the Atlantic Council of the U.S. Non-Proliferation Office, endorsed a broader ASIATOM concept to include Australia, Canada, and perhaps the U.S. He proposed a separate PACATOM which focuses initially on non-proliferation and nuclear safety, then gradually broadens its agenda to include other issues.<sup>8</sup>

With so many different and opposing strategic and economic interests operating in East Asia, the key to forming a cooperative framework is focusing on shared interests, such as:

- spent fuel storage and radioactive waste disposal (Russian Far East, Taiwan, North and South Korea, Japan, and eventually China),
- nuclear proliferation and regional security (caused by the separated plutonium in Japan, and the clandestine nuclear weapons program in DPRK),
- safe operation of nuclear facilities (this is the issue that binds all parties together because the region could not afford to have a Chernobyl-type accident),
- support for economic development, including supply of nuclear energy and fuel to East Asian countries and export of nuclear generating technologies (Japan, South Korea, and possibly later China).

## How Could a Regional Compact Help?

How could a regional compact help in getting East Asia to pursue its shared interests? The following offers a few insights:

### Shared interest: **Spent Fuel Storage/Radioactive Waste Disposal**

A regional compact could provide spent fuel storage and/or permanent radioactive waste disposal in a geologic repository; a country with nuclear power would need, at a minimum, (1) remote land, (2) financing, and (3) research and development. However, not all countries possess these essential elements at the same time. For instance, China and Russia have sparsely-populated territory but lack financing to build storage facilities and geologic repositories. Japan, South Korea, and Taiwan can afford financing and R&D but lack suitable space for storage and disposal facilities. A regional compact could provide the forum for these countries to engage in cooperative dialogue and reach an agreement for regional spent fuel and waste management.

### Shared Interest: **Nuclear Proliferation and Regional Security**

A regional compact could minimize concerns about theft and diversion of separated fissile material and help clarify the peaceful intent of a country possessing separated fissile material stock. A regional compact for nuclear cooperation could provide coordinated management and reciprocal inspection of separated fissile material stocks held by member countries. Personnel from regional countries could inspect fuel cycle and storage facilities to ensure that a regional material control regime is maintained. Such a regime could supplement IAEA safeguards and security provisions.

### Shared Interest: **Safe Operation of Nuclear Facilities**

A regional compact could develop safety regulations and standards, and provide safety inspections in operating nuclear facilities. It also could coordinate emergency response and require member countries to notify others in cases of accidents.

### Shared Interest: **Export of Nuclear Generating Technologies and Nuclear Fuel**

Like EURATOM, a regional compact in East Asia could create a common market in nuclear technology and equipment, facilitate capital investment for the development of nuclear energy, ensure regular and equitable supplies of nuclear fuel and free movement of capital and labor for nuclear work, and establish links with other countries and international organizations for peaceful use of nuclear energy.

## Criteria for an East Asian Regional Compact

The need for an East Asian Regional Compact Framework is examined here based on six criteria, each of which presents a unique challenge to nuclear energy development:

- **Energy**--Nuclear energy is a proven energy source, but can it overcome issues of waste disposal, non-proliferation, safety, and public acceptance to compete with other alternatives?
- **Environment**--Use of nuclear energy can lessen the environmental degradation from fossil energy use, but will problems of radioactive waste disposal prevent expanded development of nuclear technology?
- **Security**--Given that nuclear technology which produces civilian energy also could produce weapons-usable material, what is the most effective means to render nuclear technology proliferation-resistant?
- **Safety**--Nuclear power has an excellent safety record, but can it afford another Chernobyl-type accident?
- **Domestic Policy**--For East Asian economies, is nuclear energy justifiable as:
  - (1) part of an "energy self-reliance" policy?
  - (2) a future exportable commodity?
  - (3) a bargaining chip on security matters?
  - (4) an area of employment for displaced weapons scientists and engineers?
- **Economics**--Nuclear technology is capital-intensive. Can the operating cost and construction time be lowered relative to other fuel options to make it an economically justifiable option?

## Present and Future Nuclear Power Programs in East Asia

Using these six criteria, an examination of the current nuclear realities in China, Japan, South Korea, Taiwan, North Korea, and the Russian Far East are listed in Table 2, illustrating the complexity and diversity of nuclear issues in the region. It also indicates some of the problems current nuclear powers face with the *status quo*.

East Asia, with its ravenous appetite for electricity, is turning to nuclear energy because it is a proven, currently-available, and in many cases, economically competitive source of energy, and because--at least for many East Asian countries--alternatives are not consistently, cheaply, or conveniently available. Coal, for example, is in short supply in Japan, North and South Korea, and virtually nonexistent in Taiwan. China's supply, while abundant, is in northwestern provinces far from the centers of population and industrial/commercial developments in the south and southeastern coasts. Oil and natural gases are available, primarily from import, hence, expensive. Hydropower has limited potential for many of these East Asian countries with small geographical area. It is being developed in China, but it cannot meet the country's appetite for electricity. That makes nuclear energy one of the most accessible, practical, and economic choices for large baseload power plants, and East Asia is currently the only region in the world that has plans to rapidly expand nuclear power as a major energy source within the next century. Appendix 7 summarizes the spent fuel management programs and the back end nuclear fuel cycle policies for the East Asian region, while particular situations are discussed below.

## China

No country in East Asia has more ambitious plans for nuclear energy than China. The ambition is driven by necessity, as shown in Figure 1. With 20% of the world's population, China must determine how to produce enough electricity to meet the needs of its growing economy and 1.2 billion people. Figure 1 compares electricity consumption per capita versus population for the East Asian countries and a few other countries. It shows that China produced a total of 920 TWh

of electricity in 1995, about 30% of the United States' production. But China's 1.2 billion population is about 4 times that of the U.S., implying an average American consumes about 14 times more electricity than an average Chinese. Since per capita electricity consumption is one of the measures of standard-of-living, such disparity in electricity availability between the two economies foreshadows the great anticipated rise in Chinese energy demand.

China's nuclear capacity consists of three operating plants producing 2,100 megawatts (MWe), about 1% of the total electricity generating capacity. One, a 300 MWe pressurized water reactor (PWR) of Chinese design that went on line in 1991, is near Shanghai at Qinshan in the eastern coastal region. Two others, each 900 MWe PWRs and known as Daya Bay Units 1 & 2 built by Electricite de France (EdF) of France, are in the Guangdong province near Hong Kong. Under construction are two 600 MWe PWRs of Chinese design to add to the one already in operation at Qinshan. China has awarded a contract to a French consortium in early 1996 for the construction of two units of PWRs, similar in design to the Daya Bay units, at Ling-O, a site not far away from Daya Bay. It has also signed an agreement with Atomic Energy of Canada, Limited (AECL) on July 12, 1996 for financing and supply of two heavy water reactors (CANDU) to be built at Qinshan.<sup>9</sup> In addition, China and Russia are planning two 1,000 MWe VVERs--the Russian designed version of the PWR--in the northeastern Liaoning province. The goal for China's nuclear infrastructure is 15 to 17 gigawatts (GWe) by 2010, and 30 to 40 GWe by 2020, according to the China National Nuclear Corporation (CNNC).<sup>10</sup>

**Table 4-2: Examination of East Asian Regional Compact Based on Six Criteria**

<b>Criteria</b>	<b>China</b>	<b>Japan</b>	<b>S. Korea</b>
<b>Energy</b>	20% shortfall in electricity supply became a net oil importer in '93 rely heavily on coal for power generation	most extensive nuclear power program in Asia energy self-sufficiency based on nuclear energy	an expanding nuclear power program in Asia energy self-sufficiency based on nuclear energy develop Korean Standard Nuclear Power Plant
<b>Environment</b>	problems with pollution, health impacts, acid rain, CO2 emission, and coal ash disposal could provide regional repository for spent fuel & HLW	commits to the Rio Declaration on CO2 emission difficult to site power plants & waste facilities	difficult to site power plants & waste facilities
<b>Security</b>	a nuclear weapons state a regional power begins to build a nuclear navy will consider the participation in 4-party talks with the U.S., S. and N. Korea on security in Korean Peninsula	relies on bilateral security agreement with the U.S. will consider a larger share of regional security burden should be included in the 4-party talks on security in Korean Peninsula	relies on bilateral security agreement with the U.S. agree to engage in 4-party talks with the U.S., China & N. Korea on security in Korean peninsula concerns about Japan's plutonium use and nuclear ambition
<b>Safety</b>	no safety record revealed on its nuclear weapons program control rod problem at Daya Bay unit	sodium leak at Monju fast reactor plant otherwise, good operating safety record	good operating safety record
<b>Domestic Policy and Politics</b>	large number of nuclear personnel from weapons program capable of influencing regional & global nuclear policy	capable of becoming a nuclear weapons state commit to a closed fuel-cycle policy disputes with the U.S. on plutonium use policy	large R&D investment in nuclear technology intended for future export of nuclear business puzzles at the U.S. two-tier policy on fuel

	upset at U.S. trade sanctions on nuclear equipment	large R&D investment in nuclear technology intended for future export of nuclear business	reprocessing commits to the joint development of DUPIC with AECL
<b>Economics</b>	financing for power generation depends on domestic saving nuclear is competitive in specific coastal regions only	nuclear is competitive with other fuel sources	nuclear is competitive with other fuel sources
<b>Energy</b>	reserve capacity dips below 5% needs to build new plants awards GE to build two units of ABWRs	KEDO provides 500,000 barrels fuel oil per year S. Korea to build 2 KSNPP in 10 years	vast natural & energy resources may develop a floating reactor concept based on its nuclear submarine technology
<b>Environment</b>	LLW dump site at Orchid Island near capacity needs to find spent fuel storage sites	potential environmental damage by clandestine nuclear program	dumping of radioactive effluents in Sea of Japan is problematic storage problem with spent fuel from nuclear powered submarines and icebreakers could provide regional repository for spent fuel & HLW
<b>Security</b>	gave up a clandestine reprocessing program in the '70s due to U.S. pressure the U.S.'s Taiwan Relation Act is ambiguous in U.S. commitment on Taiwan's security security threat exerted by China	politically & economically isolated may consider to participate in a 4-party talks with the U.S., China, and S. Korea on security in Korean Peninsula concerns about Japan's nuclear ambition	maintains a nuclear navy in the Far East region
<b>Safety</b>	a fire in '84 destroyed the turbine-generator at Maanshan nuclear plant otherwise, good operating safety record	concerns on safety of its graphite-moderated reactors concerns over the 8,000 rods of spent fuel stored in wet pool	safety concerns over the submarine waste storage and disposal problems safety concerns over the floating reactor design
<b>Domestic Policy and Politics</b>	wants global political recognition on par with its economic status may restart its clandestine nuclear program (if it feels the U.S. is not committed to its security need) public opinion against building more nuclear power plants	difficult economic/political situation concerns over KEDO's long-term commitment on fuel oil supply could use its clandestine nuclear program as bargaining chip again	its Far East region is scarcely populated, and is perceived to be ignored by Moscow politics the Far East region is vulnerable to be assimilated by its neighboring states
<b>Economics</b>	nuclear is competitive with other fuel sources Taipower wants to build a U.S. reactor to offset trade surplus with the U.S.	needs external financial assistance	needs external financial assistance for energy development

Financing such ambitious growth in nuclear generating capacity is not easy. Foreign capital is essential if China hopes to build what it needs. Between 1976 and early 1990, foreign investors provided U.S.\$9 billion for power plant construction, and China hopes to attract U.S.\$3.5 billion annually in foreign capital through 2000 for power plant projects. Unfortunately, foreign investment slowed in recent years because the Chinese were reluctant to allow the high rates of return required by foreign lenders to offset the risk of investing in China. China also made it clear that it wants attractive packages which include loans to help buy state-of-the art technology and equipment.

Export of U.S. nuclear technology and equipment was plagued by U.S. domestic policy and politics. Although China and the United States signed a nuclear accord in July 1985 to allow American companies to sell nuclear-related technology and equipment to China, the U.S. Senate has not ratified the accord. The export restriction was further complicated by incidents such as the 1989 Tiananmen Square violence and China's alleged sale of nuclear-related equipment to Pakistan. At the 1997 Sino-U.S. Summit, U.S. President Clinton cleared the way for Senate ratification by certifying that China was complying with nuclear-related demands. Appendix 1 describes U.S. nuclear export controls as they apply to China. Some relaxation of export restrictions imposed on nuclear sale to China occurred recently, however, the case involved a U.S.\$137 million sale of advanced technology from Westinghouse to CNNC, relatively small compared to other Chinese purchases from France and Canada.

## Japan

The Japanese nuclear industry is now mature, needing to focus upon managing aging nuclear plants and constructing new ones. Japan's 10 utility companies are also working towards establishing a fully closed nuclear fuel cycle. This includes spent fuel reprocessing and recycling of recovered uranium and plutonium, and the commercialization of fast breeder technology by 2030. In Japan, nearly 30% of electricity is provided by 49 nuclear power plants generating 42 GWe of capacity. Japan's nuclear program, consisting of a mix of nuclear power reactors (22 boiling water reactors (BWRs), 22 PWRs, one gas-cooled reactor, one advanced thermal reactor, and one fast breeder reactor) and fuel cycle facilities for fuel enrichment, UO<sub>2</sub> and MOx fuel fabrication, and fuel reprocessing, is the most advanced in Asia.

Japan revised its long-term program for research, development, and nuclear energy in June 1994.<sup>11</sup> Its goals are to rely upon and continue to improve the LWR technology, and to boost Japan's nuclear generating capacity from 42 GWe to 46 GWe by 2000, and to 72 GWe by 2010. The nuclear generated share of Japan's electricity would rise to 33% in 2000 and 42% in 2010. The increase of electricity generating capacity would include the world's first two advanced boiling water reactors (ABWRs) at Kashiwazaki-Kariwa, one operated in 1996 and the other in 1997.

Although Japan's commitment to a comprehensive recycling strategy has not changed, its revised program scaled back its ambitious rate of fuel cycle development. Because of increased equipment prices and the need to make plants earthquake-resistant (especially after the 1995 Kobe earthquake), Japan's first commercial-size (800 Mg/y capacity) reprocessing plant at Rokkasho is 14 months behind schedule and is expected to cost twice the original estimate. Instead of the original goal of starting operations of a second reprocessing plant around 2010, Japan now expects only to make a policy decision on the project by 2010. And Japan's Atomic Energy Commission (JAEC) abandoned work on the advanced thermal reactor (ATR), including a proposed 600 MWe demonstration ATR at Ohma. The utilities proposed building a 1350 MWe ABWR with a full MOx core as a more cost-effective alternative.

A leak of the sodium coolant from the secondary cooling loop on December 8, 1995 in Japan's prototype fast-breeder reactor, Monju, prompted the immediate shutdown of the reactor, the most serious setback to Japan's plutonium-use policy.<sup>12</sup> According to projections, Japan's consumption of plutonium is supposed to reach 5 metric tons annually by 2010, including 600 kg by Monju and 700 kg by a yet-to-be-built demonstration breeder reactor. The projections are meant to be matched by the corresponding amount of plutonium supplied by the existing Tokai and the now-constructed Rokkasho reprocessing plants. If Monju is out of service for a prolonged period, that could result in an accumulation of excess plutonium and not only make Japan's self-

imposed goal of maintaining supply-demand balance of plutonium impossible, but also raise concerns for the protection of the plutonium in Japan and deepening concern in other Asian countries about the prospect of Japan developing its own nuclear weapons program. Japan's plutonium-use policy and problems are further explored in Appendix 2.

## South Korea

South Korea will have 27 operating nuclear power plants in year 2010, including four "next generation" evolutionary PWRs, according to a revised nuclear power development program for South Korea's electric power industry.<sup>13</sup> Nuclear power, in the form of 10 PWRs and one CANDU reactor, provided more than 30% of South Korea's electricity generation in 1996. The new program aims to increase that proportion to 46% by 2010, with about 190 terawatt-hours (TWh) of electricity being supplied by nuclear units.

Under the program, South Korea will complete 18 new nuclear units between 1996 and 2010, in addition to the nine already operating. Among the new planned additions, 11 will be Korean standard nuclear power plants, a 1000 MWe PWR based on ABB-Combustion Engineering's System 80 design; three will be 700 MWe pressurized heavy-water reactors (PHWR) supplied by Atomic Energy of Canada, Limited (AECL); and four will be 1300 MWe evolutionary PWRs, destined to be South Korea's second standardized design (the Korean next generation reactor, KNGR).

Because South Korea has meager fossil fuel resources, nuclear energy was chosen to be the country's dominant electricity source. After the 1970s oil shock, South Korea made a deliberate decision to develop its own nuclear expertise and since launching a national policy of energy independence in the 1980s, its energy goal includes reducing dependence on foreign energy technology and equipment too. Self-reliance on nuclear energy requires expertise in nearly all areas of nuclear technology: design, procurement, equipment manufacturing, construction, installation, start up, operation and decommissioning. South Korea desired to obtain its own nuclear supply infrastructure from an early stage, including Nuclear Steam Supply System (NSSS) engineering and manufacturing capability. Its first two turnkey Westinghouse PWRs and its first pressurized heavy water reactor (PHWR) from Atomic Energy of Canada Ltd. (AECL) were projects with few domestic industries participating in the construction of the plants. But since then, South Korea gradually shifted its contractual practices to component-based construction, insisting upon foreign technology transfer to Korean firms as the major condition for project awards. The South Koreans adopted and modified the ABB-Combustion Engineering's System 80 PWR, and renamed the enhanced version the Korean Standard Nuclear Power Plant (KSNPP). Other technology purchases were made from General Electric for turbine generators, Sargent & Lundy for architect/engineering work, Siemens AG for PWR fuel fabrication, and French industry for waste management, PHWR fuel fabrication, and uranium conversion. South Korea is now developing the design for a next-generation reactor (KNGR) planned for operation in 2007, based on an advanced ABB design. It also is cooperating with AECL of Canada to research a range of advanced fuel cycles, including the unique tandem fuel cycle, where PWR spent fuel is reused directly in CANDU reactors. Appendix 3 describes South Korea's research collaboration with AECL on DUPIC technology.

South Korea also wishes to export nuclear technology to other countries, having already won consulting contracts in China and Turkey, and negotiating with China for the supply of reactor pressure vessels (RPVs) in China's future nuclear power plants.

South Korea's nuclear program faces numerous challenges. Domestically, the biggest hurdle is finding new plant sites and waste storage/disposal sites, while public acceptance of nuclear power and public awareness of nuclear safety issues have intensified. Economically, nuclear plant construction costs for new units are expected to increase because of stricter safety provisions. Internationally, transfer of sensitive nuclear technologies such as fuel reprocessing and enrichment are a stumbling block to South Korea's self-reliance. South Korea's intention to be self-sufficient in the nuclear fuel supply is apparent since it is now manufacturing PWR assemblies at a plant originally supplied by Siemens AG, and it is interested in spent-fuel reprocessing and recycling to minimize import costs of uranium. Having developed much of its

nuclear technology in cooperation with U.S. industry, South Korea has not provoked the U.S. by seeking reprocessing capability. However, it has sought reprocessing-related technology--without success--from Canada and the U.S., and held talks with Russia about reprocessing South Korean spent nuclear fuel at an incomplete facility (RT-2) at Krasnoyarsk in Siberia.

Like Japan, South Korea bristles at U.S. criticism of its nuclear self-reliance policy. For instance, the U.S. in 1992 refused a South Korean request to expand the use of a French-supplied post-irradiation examination facility for anything but U.S.-origin fuel. In 1985, the U.S. had set a 12-bundle limit on the total amount of U.S.-supplied fuel that could be handled in this facility, a restriction that expired in 1996. Given South Korea's criticism of the U.S. two-tier policy on fuel reprocessing (allowing Japan to reprocess U.S.-supplied fuel, but not Korea), South Korea may ask for removal of this restriction as part of a request for equal treatment.

## Taiwan

Reliable and inexpensive energy supply is crucial to Taiwan's reliance on continuous economic development. Taiwan, a small island with little energy resources, must import more than 90% of its energy. A lack of new methods of electricity generation since the early 1980's--caused by strong domestic political and environmental movements--caused the reserve generating capacity of the state-owned Taiwan Power Company (Taipower) to drop below 5%, well below the 15-20% reserve margin considered prudent in the U.S. utility industry.

Taipower operates four BWRs and two PWRs at three different sites, with a total installed capacity of 5144 MWe, roughly 35% of the island's electricity. Although the island's domestic politics has recently turned negative toward the expansion of nuclear power because of Chernobyl, the development of safe, clean nuclear power is still necessary for Taiwan to provide sufficient energy supplies in the future.

Taipower awarded in June 1996 the Lungmen contract to General Electric for two units of ABWRs each rated at 1355 Mwe and scheduled for commercial operation by 2005.<sup>14</sup> Whether the Lungmen project gets built, however, is not certain. The deal can be voided if Taipower does not give GE approval within four months. Majority support in Taiwan's parliament for the project is still needed to overcome opposition to this project. However, Taiwan's pro-nuclear governing Nationalist Party is losing its dominance in the island's parliament, and newly formed political parties are mostly anti-nuclear. These conflicts need to be resolved for nuclear power to maintain its share of Taiwan's energy needs.

Another concern is Taipower's spent nuclear fuel management problem. Since the establishment of the nuclear back end fund in 1986 (current collection basis is roughly 6 mills/kWh with the planned total amount being U.S.\$5-6 billion), little has been achieved. Taipower has held discussions with Russia, the Marshall Islands, and China regarding spent-fuel storage services, but no deal has been struck. Several sites for low-level wastes in Taiwan were denied because of opposition from local communities. Finally, Taipower signed a deal in 1997 with North Korea to ship 200,000 drums of low-level waste at a reported cost of \$230 million. South Korea and China, citing possible health hazards and fears of inadequate DPRK safety provisions, strongly opposed the plan. With China exerting pressure on Taiwan's future, the decision on how to handle the back end of the nuclear fuel cycle becomes a technical as well as a security issue for Taiwan. Managing Taiwan's spent fuel and radioactive waste is further explored in Appendix 4.

## North Korea

North Korea obtained most of its nuclear knowledge and technical assistance from the Soviet Union. Under terms of its 1959 nuclear cooperation agreement, North Korea received a 2 MWt research reactor and a critical assembly from the Soviets. North Korean scientists expanded the reactor capacity to 8 MWt using their own indigenous technology, producing radioactive isotopes for scientific research, and industrial and medical purposes. In 1984, North Korea began construction of a 50 MWe gas-cooled, graphite-moderated power reactor based on natural



uranium. In 1986, North Korea also commissioned a 5 MWe indigenous experimental reactor at the Institute of Nuclear Physics in Yongbyon based upon a gas-graphite design of the 1940s, similar to the Calder Hall reactor in the U.K.

In 1987, North Korea began the construction of a so-called "radiochemical laboratory" designed for research on the separation of uranium and plutonium, waste management, and the training of technicians. The facility is capable of reprocessing 200 tons of spent nuclear fuel per year. During this period of rapid nuclear development, North Korea built more than 100 various nuclear facilities in Yongbyon, including a uranium mining facility, a uranium purification plant, an enrichment plant for low-enriched uranium, and a subcritical facility at Kim Il Sung University.

North Korea joined the International Atomic Energy Agency (IAEA) in September 1974, and signed the Nuclear Non-proliferation Treaty (NPT) in December 1985 under pressure from the Soviet Union. In 1992, North Korea signed a bilateral declaration with South Korea on the denuclearization of the Korean Peninsula, and jointly committed not to operate uranium enrichment or plutonium separation facilities on their territories. However, North Korea never allowed the IAEA to verify its initial inventory of fissile material produced in its indigenous reactors. IAEA's inspections of North Korea's nuclear facilities at Yongbyon in 1992 revealed North Korea's continued expansion of a clandestine reprocessing plant, violating its NPT obligations, and in response, South Korea rejected the bilateral declaration on the denuclearization of the Korean Peninsula. The confrontation between North Korea and IAEA in subsequent inspections, especially about whether North Korea would reprocess spent fuel discharged from its graphite-moderated reactor and allow IAEA to conduct special inspections, resulted in North Korea's decision to withdraw from the NPT regime in March 1993.

North Korea formally requested direct negotiations with the United States on the nuclear issues and both sides signed a statement in Geneva in 1993 which rescinded North Korea's withdrawal from the NPT in return for a U.S. pledge not to use or threaten to use nuclear weapons against North Korea.<sup>15</sup> But negotiations to get North Korea to abandon its clandestine weapons program and dismantle its graphite reactor fell through because of South Korean reservations. Following a prolonged period of political tensions, talk of economic sanctions, and a heightened state of military alert on the peninsula, U.S. and North Korean negotiators signed their Agreed Framework on October 21, 1994. The Korean Peninsula Energy Development Organization (KEDO), founded on March 9, 1995, was the international organization established to implement most of the Agreed Framework, which arranges for the complete dismantlement of North Korea's nuclear weapons program and the construction of two 1,000 MWe Korean standard nuclear power plants in North Korea. Appendix 5 describes KEDO's mission and its challenges ahead.

## Russian Far East

Russia operates four EPG-6 reactors at Bilibino on the Chukchi Peninsula, about 100 miles north of the Arctic Circle in the Russian Far East. Each of the Bilibino units has a capacity of 11 MWe. The first units began operation in 1974, were designed to operate for 30 years, with the first one scheduled for decommissioning in 2003. Russian plans call for expanding power generation capacity at Bilibino to 120 MWe. One plan would replace the four 11 MWe reactors with three 40 MWe reactors. Another under study by MINATOM would involve construction of floating nuclear power plants similar to those used in Russia's nuclear-powered icebreakers. The floating power plants would be built in a shipyard and towed to northern Siberian locations such as Bilibino, but it is uncertain whether or when funds would be available for these projects.

Russia's civilian nuclear program is relatively small in its far eastern region. However, the Russian Far East is home to Russia's Pacific nuclear fleet, consisting of one-third of Russia's active fleet of nuclear-powered submarines, icebreakers, and surface supply ships. Russia's nuclear fleet is the largest in the world, with a total of 140 vessels at the end of 1994. A somewhat larger number of nuclear-powered vessels make up the inactive fleet, much of which consists of submarines awaiting dismantlement and disposal of their nuclear fuel, reactor compartments, and radioactive wastes. Maintaining an active fleet of nuclear-powered

submarines requires that the reactor cores be refueled on a regular basis. But the Russian navy is facing significant delays in defueling/refueling submarines because of:

- **Lack of fuel transfer and storage equipment**--The breakup of the Soviet Union disrupted equipment supplies;
- **Saturation of the spent fuel storage capacity**--The central on-shore storage facilities in many of the navy ports and temporary storage compartments on board the service ships are full. In some cases, spent fuel was stored in floating reactor compartment of the inactive submarines docked alongside the pier, creating risks of radioactive releases.
- **Difficulties of removing spent fuel from submarines with damaged reactor cores**-- There are three submarines in the Pacific fleet that cannot be defueled because of damaged reactor cores. Major portions of these submarines may have to be disposed of as wastes. However, the Russian Far East region lacks the financial and technical resources to deal with this problem.

Russia faces problems not only with spent fuel, but also the need to dispose of liquid and solid wastes.<sup>16</sup> More than 12,000 cubic inches of liquid radiation wastes and 7,000 cubic inches of solid intermediate and low-level wastes were dumped in the Sea of Japan (East Sea) and near the Kamchatka Peninsula. Radioactive releases from an accident aboard a nuclear-powered submarine in Chazhma Bay during refueling and the loss of a radioactive thermal generator (RTG) during transport near Sakhalin Island increased the level of radioactive contamination in the far eastern seas. The difficulty of disposing three nuclear-powered submarines and their damaged reactor fuel remains another environmental concern. The degree of this contamination already existing in the Sea of Japan (East Sea) and its effects on the marine resources surrounding this semi-enclosed body of water are discussed in Appendix 6.

### Proposed Solution: A Regional Compact

Given global trends toward more regional economic developments, security arrangements, and collaborations on safety issues transcending national boundaries, one possible solution to the problems faced by current East Asian nuclear powers is the formation of a regional framework for nuclear cooperation. Table 2 presents the motivations and concerns each East Asian state might have in joining such a nuclear compact framework.

Besides examining specific country motivations for an East Asian Regional Compact, we must further explore the following regional questions:

(1) Is now the right time to establish a nuclear cooperative framework in East Asia?

Yes, if one wishes to resolve the problems which hinder development of nuclear energy in East Asia. However, understanding the differences in the level of nuclear development among East Asian countries (some have reached an advanced stage, while others are in the initial stages of development), it may be unwise to rush into forming a massive organization in which managing the different interests could become impossible.

**Table 4-3: Pros and Cons of East Asian Regional Compact**

<b>PROS (to have a regional framework)</b>	<b>CONS (status quo)</b>
<b>CHINA:</b>	
Active and constructive participation in the regional cooperative framework would assure China's leadership role in decision-making on regional nuclear matters.	The U.S. exerts most of the influence to East Asia on regional nuclear matters through bilateral agreements with regional countries. Nuclear trade with China is prohibited because of conflicts with other policy issues.

Favorable financial support and assistance from regional countries based on the regional framework agreement could offer China the most needed financial resources for a balanced energy-use policy.	Lack of financial support to develop China's nuclear program could make China depend more on its coal for energy use, resulting in vast environmental impact.
Through the regional framework, China could exert its influence on regional safeguards and security issues and military intentions of other regional countries.	China's influence on other regional countries' nuclear program, safeguards and security matters and military intentions is limited.
Safety certification of China's indigenous nuclear plant design by the regional framework agreement could enhance its marketability.	Without safety certification, the market of China's indigenous nuclear plant could be limited only to third world (or even rogue) countries.
China could earn financial compensation if it offers the regional countries fuel-cycle services such as spent-fuel management and disposal, fresh fuel fabrication, and enrichment services, etc. Such services would ensure short distance of transportation of nuclear materials (as compare to shipping to and from the U.S.), and hence, lessen the concerns for transportation safety and safeguards and security.	Several East Asian countries have problems of indefinite-storing and disposing their spent nuclear fuel. Shipping these fuels back to the original fuel-supplying countries (mainly the U.S.) is either not acceptable, or could result in long distance of transport, imposing safety and security concerns.
A regional multilateral framework agreement could be more effective than the current bilateral agreements in resolving regional conflicts in nuclear matters.	Most of the existing bilateral agreements with the U.S. are ambiguous, and often inconsistent. For example, the U.S. approves Japan's fuel-reprocessing program, but disallows S. Korea and Taiwan to pursue their fuel reprocessing options.
<b>JAPAN:</b>	
A regional framework could enhance Japan's leadership role in providing advanced nuclear technology, financial support, safety training, and research and development to other regional countries.	The bilateral nuclear and security agreement between the U.S. and Japan dictates much of Japan's nuclear policy. It also hinders Japan's intended goal to be the primary nuclear technology supplier for the East Asian region.
A regional framework would promote transparency of regional nuclear programs and allow coordinated inspection of regional fuel-cycle facilities, and hence, would lessen other regional countries' concerns on Japan's nuclear program.	Many Asian countries are still suspicious of Japan's nuclear program, especially in regards of the separated plutonium currently stocked in Japan. This could have a destabilization impact to regional security, notably, to nuclear programs in the Korea Peninsula.
Through the regional framework, Japan not only secures its own nuclear fuel supply, but also assures other's stable and reliable fuel supply by means of its advanced fuel enrichment and fabrication facilities.	Japan's pursuit of "nuclear fuel self-sufficiency" by domestic enrichment of uranium would be scrutinized by the U.S. and other regional countries because of safeguards and security, and "real" nuclear intent.
If a regional spent-fuel storage facility and ultimately, a regional repository are available through the regional framework agreement, Japan's problem of spent-fuel storage and waste disposal could be resolved.	Opposition to siting of a waste repository in Japan's densely-populated islands could prolong the debate for a waste disposal program, and adversely impact the growth of its nuclear program.
With a regional framework agreement in place, Japan could be more assertive in implementing a safety culture for the region, and demanding compliance with international regulations and standards from other regional countries' nuclear operations.	Currently, there is not much coordination among regional nuclear programs in East Asia, especially, in the area of safety implementation. The region is in need of a safety culture to assure that nuclear accidents would not occur.
<b>SOUTH KOREA:</b>	
A regional framework could enhance South Korea's role in providing advanced nuclear technology, financial support, safety training, and research and development to other regional countries.	The bilateral nuclear and security agreement between the U.S. and S. Korea dictates much of S. Korea's nuclear policy. It also hinders much of S. Korea's own developmental nuclear program.

<p>A regional framework would promote transparency of regional nuclear programs and allow coordinated inspection of regional fuel-cycle facilities, and hence, would lessen the concerns by the U.S. and other regional countries on S. Korea's research on a DUPIC fuel-cycle.</p>	<p>The U.S. has steadfastly opposed S. Korea's intent of reprocessing its spent nuclear fuel, and may again oppose S. Korea's program for a DUPIC fuel-cycle on ground of nuclear proliferation. This policy would continue offending the S. Korean because of discriminatory bias, it allows Japan to fuel-reprocessing, but not S. Korea.</p>
<p>Through the regional framework, S. Korea would have more alternatives in securing its nuclear fuel supply.</p>	<p>S. Korea would continue relying on the U.S. (or the West) for nuclear fuel-supply.</p>
<p>If a regional spent-fuel storage facility and ultimately, a regional repository are available through the regional framework agreement. S. Korea's problem of spent-fuel storage and waste disposal could be resolved.</p>	<p>Opposition to siting of a waste repository in S. Korea's densely-populated and geographically small country could adversely impact the growth of its nuclear program.</p>
<p>With a regional framework agreement in place, S. Korea could be more assertive in promoting its Korean Standard Nuclear Power Plant design to regional countries. Hence, S. Korea's influence on implementing a safety culture for the region could be enhanced.</p>	<p>Currently, there is not much coordination among regional nuclear programs in East Asia, especially, in the area of safety implementation. The region is in need of a safety culture to assure that nuclear accidents would not occur.</p>
<p><b>TAIWAN:</b></p>	
<p>A regional framework could provide Taiwan a forum in promoting the peaceful application of nuclear energy, and voicing its support or opposition to nuclear programs in other regional countries.</p>	<p>Taiwan's current nuclear power program is for peaceful energy application. It does not have much influence on other regional countries' nuclear programs.</p>
<p>Through the regional framework, Taiwan would have more alternatives in obtaining its nuclear fuel supply.</p>	<p>Taiwan would continue relying on the U.S. (or the West) for nuclear fuel-supply.</p>
<p>If a regional spent-fuel storage facility and ultimately, a regional repository are available through the regional framework agreement, Taiwan's problem of spent-fuel storage and waste disposal could be resolved.</p>	<p>Opposition to siting of a waste repository in Taiwan's densely-populated and geographically small island could adversely impact the growth of its nuclear program.</p>
<p>With a regional framework agreement in place, Taiwan could be more indebted in sharing its safe operation practices with other regional countries.</p>	<p>Currently, there is not much coordination among regional nuclear programs in East Asia, especially, in the area of safety implementation. The region is in need of a safety culture to assure that nuclear accidents would not occur.</p>
<p><b>RUSSIAN FAR EAST:</b></p>	
<p>A regional framework could provide the Russian Far East a forum in obtaining financial assistance to manage its nuclear legacy of spent submarine fuel and the associated process wastes.</p>	<p>Russia has an acute problem managing its spent submarine fuel and wastes generated by its Pacific Fleet located in the Far East region. The dumping of radioactive effluents into the Sea of Japan has met with fierce objection from regional countries.</p>
<p>Russia could earn financial compensation if it offers the regional countries a spent-fuel storage facility, and ultimately a regional waste repository in its Far East region. Such services would provide a solution to its own spent-fuel disposal problem, and ensure short distance of transportation of spent fuel and wastes from other regional countries (as compare to shipping to the U.S. or Europe). Hence, it would lessen the concerns for transportation safety and safeguards and security.</p>	<p>Russia lacks financial resources for the management of its spent-fuel and wastes in the Far East region. Its rail transport system is too old and unreliable to ship the spent-fuel and wastes out of the region. The persistence of the problem would increase the likelihood for a major nuclear contamination event involving these material to occur.</p>
<p>The regional framework would provide an additional forum for Russia to exert its military influence on regional security in the Far East region.</p>	<p>Russia maintain its military presence in its Far East region by its Pacific Fleet, although Russia's internal economic difficulty may have limited its power projection function.</p>

Favorable financial support and assistance from other regional countries based on the regional framework agreement could offer Russia the most needed financial resources to develop the vast amount of natural and energy resources in its Far East region.	Lack of financial support to develop the natural and energy resources in the Russian Far East could continue hindering Russia's economic development for the region, making the region less-populated, and more vulnerable to be assimilated by neighboring countries.
<b>NORTH KOREA:</b>	
A regional framework could provide N. Korea a forum in obtaining financial assistance to manage problems associated with its indigenous nuclear program.	N. Korea has an acute economic problem. The Korean Peninsula Energy Development Organization (KEDO), set up under the bilateral 1994 Agreed Framework to assist N. Korea's energy need is facing continuous and serious financial challenge that may threaten its viability.
If a regional spent-fuel storage facility is available through the regional framework agreement, spent fuel from N. Korea's graphite reactor could be sent there, lessening the concern that these fuels would be reprocessed for military use.	Spent fuel from the graphite reactor is currently stored in water pool in N. Korea, subject to continuous corrosion and degradation, threatening workers' health and safety, and increasing the environmental contamination concern.
The regional framework could provide an additional forum for N. Korea to work with S. Korea in building the Korean Standard Nuclear Power Plants on N. Korean soil.	N. Korea has insisted that it will not seek help from S. Korea on a bilateral basis. KEDO may provide a workable forum, however, KEDO's own viability is in doubt because of financial concern.
A regional framework agreement may encourage N. Korea to further abandon its clandestine nuclear weapons program, and to more adhere to regional and international non-proliferation efforts.	N. Korea was intended to seek diplomatic recognition through its clandestine nuclear weapons program. If KEDO fails to meet its obligations under the 1994 Agreed Framework, N. Korea could claim default on the part of KEDO and restart operation and construction of its nuclear weapons program.

(2) What kind of regional framework is appropriate for East Asia?

Among proposals for a nuclear cooperative framework in East Asia, the most mentioned are labeled "Asian equivalent of EURATOM," "ASIATOM," and "PACIFICATOM." The main differences among these proposals are reflected in the names chosen, i.e., whether the regional framework includes only Asian countries, or only Asia-Pacific countries, or Asian countries plus prominent nuclear countries such as the U.S., Canada, and France.

For reasons of economics and safety, much of the routine handling and shipment of nuclear materials should be carried out on a regional basis, with a region being large enough to include countries with the needed facilities but compact enough to minimize costs and risks associated with shipments among them. Both ASIATOM and PACIFICATOM may include too large of an area and encompass too many countries.

The East Asian Regional Compact is proposed here without a specific nameplate (such as ASIATOM or PACIFICATOM) for reason of flexibility, especially in its early stages of dialogue about its formation. The regional compact includes those areas currently possessing nuclear programs in East Asia (China, Japan, North and South Korea, Taiwan and the Russian Far East). These six share proximity, mutual security interests, interdependent economic objectives, and common energy needs, but also harbor hostility and distrust against each other resulting from historical perspectives, potential military confrontation, competition for natural and energy resources, and territorial disputes. The likelihood for forming a regional cooperative framework in East Asia would depend not only on the goodwill and desires of the parties to join, but also the participation of the United States, a country of enormous nuclear influence in the region. The inclusion of the U.S. in the East Asian Regional Compact is most important in the formative stages of the framework, with the U.S. playing a

catalytic role. An East Asian cooperative framework would benefit the U.S. because a stable nuclear East Asia is in the interest of U.S. national security.

(3) What is the United States' role in an East Asian regional compact?

The U.S. should play an active role in an East Asian regional compact because the U.S. still is the major provider of nuclear fuel and equipment to the region. Many factors could affect its role, and the primary ones are discussed below:

**Bilateral vs. Multilateral**--Historically, the United States signed bilateral agreements with East Asian countries. These included security agreements with Japan and South Korea, and the Taiwan Relations Act with Taiwan. Each of these agreements serves a unique purpose, and together, they form an important piece of U.S. foreign policy in assuring the region's security.

On nuclear trade and cooperation, the U.S. supplied fuel and equipment to Japan, South Korea, and Taiwan. American nuclear power plant designers and manufacturers signed joint R&D contracts and agreements with their Japanese and Korean counterparts, transferring nuclear technologies and knowledge. There is also the yet-to-be-implemented U.S. nuclear accord with China, signed in 1985.<sup>17</sup> And in October 1995, the U.S. signed the Agreed Framework with North Korea, resulting in the DPRK abandoning its indigenous nuclear-weapons program in exchange for U.S. providing fuel oil and South Korea building two KSNPPs in North Korea.

On environmental decontamination, the U.S. and Russia signed the Gore-Chernomyrdin Agreement on Cooperation on Environmental Restoration in the North Pacific to clean the Russian radioactive legacy in the Sea of Okhotsk and the Sea of Japan (East Sea).

This spectrum of bilateral agreements illustrates the dimensions of American involvement in East Asia's security, nuclear energy, and environment. It also indicates the U.S.-preferred bilateral approach to foreign policy. However, these bilateral agreements fail to address current issues such as nuclear waste management and nonproliferation introduced by the expansion of nuclear power in the region. Therefore, a multilateral approach is warranted to seek a resolution to regional nuclear problems. The U.S.-DPRK Agreed Framework is one example of how an original bilateral agreement can evolve into a multilateral forum. The U.S. signed the Agreed Framework to defuse the proliferation potential of North Korea's clandestine nuclear weapons program. However, it would take years before North Korea dismantles its capacity to make nuclear weapons. Meanwhile, North Korea's food shortage might trigger internal political turmoil and spark a regional crisis. In an attempt to avert such a crisis, in April 1996, the U.S. and South Korea proposed Four Party Talks (2+2), involving the two Koreas, the U.S. and China (as signatories to the Armistice Agreement that ended the Korean War) to create a multilateral framework for inter-Korean dialogue. Such a proposal also should include Japan and Russia.<sup>18</sup>

**Front end Nuclear Fuel Cycle**--The front end of the nuclear fuel cycle refers to the acquisition of fresh nuclear fuels. In many East Asian countries, nuclear fuel is generally acquired from and prepared by commercial industries operating in the international market. The U.S. is the world's largest uranium-enrichment and LEU fuel supplier and thus can dictate back end policies of many of the East Asian reactor operators by demanding consent rights of U.S.-origin fuel (or any non-U.S.-origin fuel which resides in reactor cores with U.S.-origin fuel).

However, the global uranium enrichment market is undergoing a number of significant changes making uranium enrichment a global commodity tied more to the principle of supply-and-demand and less to non-proliferation constraints. Appendix 7 describes in more detail these changes. As a result, the U.S. might lose its market share of future enrichment services and have less control over nuclear policies. Therefore, it would be prudent for the U.S. to consider a multilateral framework to ensure its nuclear non-proliferation objectives still are maintained.

**Managing the Back end of the Nuclear Fuel Cycle**--The back end of the nuclear fuel cycle refers to the management of spent nuclear fuel discharged from reactors. This includes interim and on-site spent fuel storage, spent fuel transportation and long-term storage and disposal, spent fuel reprocessing and recycling, and long-term disposal of reprocessed HLW.

According to its nonproliferation policy, the U.S. neither reprocesses spent fuel nor encourages others to do so. Exceptions to this policy were given to EURATOM and Japan, allowing them to reprocess spent U.S.-origin fuel. But the U.S. continues to exercise control on

the back end of the nuclear fuel cycle with other East Asian countries (especially South Korea and Taiwan). The U.S. will not allow them to reprocess spent U.S.-origin fuel and will not reclaim this spent U.S.-origin fuel because of U.S. public objections. As the on-site spent fuel storage pools in these foreign reactors fill up, pressure to find interim storage and long-term solutions grow. Dry cask storage could be an interim storage option provided that the local communities where the casks are stored do not object. Appendix 8 summarizes the spent fuel management programs in East Asia. With American interest in imposing its non-proliferation goals and inability to take back spent U.S.-origin fuel, it would be prudent for the U.S. to be involved in a multilateral compact seeking solutions to the problems of spent fuel storage and radioactive waste disposal in East Asia.

## Pursuing a Regional Compact for Nuclear Cooperation in East Asia

The region of East Asia is unique in its cultural backgrounds, economic systems, historical perspectives, and nuclear program developments. A model similar to EURATOM may or may not be suitable for East Asia. Instead of rushing into forming a EURATOM-like organization, a realistic and appropriate first step would be to set up fora (or work groups) where countries can engage in dialogue on nuclear energy, environmental awareness, nuclear nonproliferation, nuclear safety, spent fuel and radioactive waste management, and economic cooperation. The outcomes of the dialogue would be used to formulate appropriate consensus for a cooperative framework for East Asia.

Therefore, the key to pursuing a regional compact framework for nuclear cooperation in East Asia is not to specify a particular nameplate (such as EURATOM-like, or ASIATOM, or PACATOM, etc. where members are represented by countries and states), but to preserve flexibility and informality so that mutual interests and common problems can be discussed and resolved. In other words, China and Taiwan could be members of the compact solving Taiwan's radioactive waste problem without concern for status or representation, and North and South Korea could also be members discussing the nuclear proliferation issues for their mutual benefit.

Understanding the sensitivities of cultural differences, historical backgrounds, political hostility, and economic interdependence in East Asia, it would not be easy to gather such a group of representatives together in a forum to discuss shared interests and resolve common problems. This is where the United States can play an important role in the formation of an East Asian regional compact.

### **The United States**

The U.S. can be an effective mediator during the formative phase of an East Asian regional compact because of its enormous nuclear influence and its military presence. As discussed in previous sections, an East Asian nuclear framework should benefit the U.S. because a stable nuclear East Asia is in the interest of U.S. national security and resolving the problems of regional spent fuel storage and radioactive waste disposal also fit U.S. nonproliferation policy. As U.S. nuclear nonproliferation goals are met, this should allow relief of existing export controls and restrictions on nuclear generating technologies and equipment, allowing U.S. nuclear firms to fully participate in East Asia's nuclear market, as well as the emerging market in the ASEAN countries.

### **China and Taiwan**

China would be an essential member of an East Asian regional compact. Its status as a nuclear weapons state, its ambitious plans for increasing its civilian nuclear capacity, and the availability of vast areas of low population-density land suitable for siting of spent fuel storage and radioactive waste disposal make China an important member in the formation of the compact, qualifying it as a potential host country.

The political dilemma between China and Taiwan affects Taiwan's nuclear waste problem. China would like to handle Taiwan's nuclear waste as part of a strategy to pressure Taiwan into close cooperation, but Taiwan is not willing to depend on China as the only solution to its waste problem. As discussed in Appendix 4, an East Asian regional compact could offer a

forum for China and Taiwan to engage in bilateral and multilateral dialogues to resolve Taiwan's waste problem.

### **Japan and South Korea**

Japan and South Korea would be the technological leaders for an East Asian regional compact. Because of their advanced capabilities in nuclear technologies, they should lead in cultivating a safety culture for the region, initiating and promoting nuclear research and development, training of operating personnel, and coordinating emergency response to regional nuclear incidents.

Japan, because of its large economy, should lead the effort of creating an East Asian regional development banking network to lend favorable loans to regional nuclear energy developmental programs. South Korea, as the only country in the world operating PWRs and CANDU reactors, should lead the effort of further advancing the combined technologies, especially R&D into DUPIC technology.

### **North Korea and the Russian Far East**

Civilian nuclear programs in North Korea and the Russian Far East are small and limited. They would be minor members of the compact when forums and dialogue are engaged in the resolution of common nuclear problems brought about by the region's civilian nuclear programs. Their involvement in the compact would add other dimensions, including regional security and environmental contamination. The safety of the nuclear facility operations in North Korea, what to do with DPRK's spent fuel rods at Yongbyon, and the spent naval fuels accumulated in naval shipyards and decommissioned submarines in the Russian Far East are of great concern to the region. Solutions to these problems could be negotiated within a multilateral framework.

Suitable sites for spent nuclear fuel storage and radioactive waste disposal could be available in Russia's sparsely-populated Far East. If and when Russia decides to lift its ban on importing foreign wastes for storage or disposal, Russia could compete with others (possibly China) for providing such services.

Meetings and forums involving representatives from the U. S could be held regularly during the nascent phase of an East Asian regional compact. In the beginning, meetings should involve energy policy planners, academic experts, and nuclear industry representatives to explore the feasibility of forming a compact. Later meetings could be held in a track two format (including additional representatives from each country's foreign ministries and defense departments attending the meeting in his/her personal capacity and voicing his/her personal viewpoints).

The dialogue phase for the compact could be three years, and at the end of this phase, a decision about whether or not to form an East Asian regional compact should be made. For a positive decision, a formal organization, including representatives from the U.S, could be established to perform activities essential to the East Asian regional compact.

## **Formation of an East Asian Regional Compact**

Activities essential to the objectives and the formation of an East Asian regional compact are:

### **Radioactive Waste Management**

- to select a host country (or countries) for the provision of spent-fuel storage and radioactive waste disposal;
- to set agreeable criteria for contracts and financial compensation to the host country(ies) for providing such services. Cost figures such as U.S.\$1500 (1984\$) per kgHM of spent fuel or U.S.\$3633 (1996\$) per drum of LLW could be used as references. Arrangements such as the proposed International Monitoring Retrievable Spent Fuel Storage (IMRSS) system should also be considered;<sup>19</sup> and
- to initiate and implement research and development programs on waste disposal, essential for determining the proper back end nuclear fuel cycle policy.



## **Nuclear Non-proliferation**

- to establish a regional SNM monitoring and control regime;
- to promote transparency of regional nuclear programs;
- to provide coordinated management and inspection of separated SNM by technical experts from regional countries, complementing IAEA safeguards and security programs;
- to establish a network of fuel cycle facilities, adhering to the region's back end nuclear fuel cycle policy and the SNM control regime; and
- to ensure the reliable supply of fresh nuclear fuel and the receipt of spent nuclear fuel to and from the fuel cycle facilities of the member countries, and safeguards and security for transport of these materials.

## **Nuclear Safety**

- to cultivate and enforce a regional safety culture for nuclear facility operations, based on acceptable international regulations and standards;
- to develop prudent safety practices, and provide training to regional personnel;
- to coordinate regional emergency response to radiation release accidents; and
- to ensure safety in transporting nuclear materials in international waters and across national boundaries.
- Economic Cooperation
- to establish a regional development banking network for lending favorable loans to regional nuclear energy developmental programs; and
- to promote regional economic cooperation through a stable, economic, and environmentally accepted source of nuclear energy.

The conducting of these activities and the possible complexity involved would be topics of future studies.

## **Conclusions**

This study concludes that the fast growing East Asian economies and populations give rise to a ravenous appetite for energy, especially for electricity. The region is turning to nuclear energy to help power its economic development and increase the regional standard-of-living. Nuclear power is proven, currently available, and in many cases, economically competitive to other sources of energy, because for many East Asian countries, the alternatives are not always consistently, cheaply, or conveniently available. Nuclear energy, once deemed as a cheap, abundant and environmentally benign energy source, has been plagued by waste disposal problems, safeguards and proliferation concerns, safety issues, and expensive capital costs. To overcome these barriers, a regional compact framework is proposed.

The East Asian regional compact proposed here does not carry a specific nameplate (such as EURATOM-like, ASIATOM or PACIFICATOM, etc.) for reasons of flexibility, especially in the early dialogue stage essential for the formation of such a framework. The regional compact should include China, Japan, North and South Korea, Taiwan and the Russian Far East. They are the current nuclear establishments in East Asia, and are selected because of their close proximity, mutual security interests, interdependent economic objectives, common energy needs, and common environmental and waste disposal concerns.

This study argues that the bilateral approach preferred by many countries for conducting their foreign policies may not be adequate to address current nuclear issues such as nuclear waste management and nuclear proliferation introduced by the expansion of nuclear power programs in the region. A multilateral approach could be warranted in an attempt to seek resolutions to these multifaceted problems.

The likelihood of forming a regional cooperative framework in East Asia would depend not only on the goodwill of the countries and their desires to join but also requires the participation

of the United States, a country with enormous nuclear influence and military presence in the region. The inclusion of the U.S. in an East Asian regional compact is most important in the formative phase. U.S. leadership could draw these East Asian countries together to engage in cooperative dialogue on shared interests.

An East Asian cooperative framework is in the interest of resolving the problems of regional spent fuel storage and radioactive waste disposal fits the goals of U.S. nonproliferation policy. And eventually, a successful compact might be beneficial to the U.S. nuclear industry, allowing it to participate in the growing nuclear market in East Asia.

Finally, this study outlines the activities which are essential to meet the objectives of an East Asian regional compact, to be carried out by a formal organization staffed by East Asian and American representatives. How to conduct these activities and the possible complexity involved are topics of future studies.

## APPENDIX 1: U.S. NUCLEAR EXPORT CONTROLS TO CHINA<sup>20</sup>

### **Background**

The United States and China signed an agreement of cooperation pursuant to the Atomic Energy Act on July 23, 1985. However, the implementation of the agreement was blocked, at least temporarily, by congressional resolution prohibiting export of any nuclear material, facilities or components to China until the U.S. President could certify that:

- Such material, facilities or components would be used solely for peaceful purposes; and
- China's nuclear non-proliferation policy did not violate the Atomic Energy Act.

The implementation of the agreement was blocked indefinitely by a 1989 statute condemning the "unprovoked, brutal and indiscriminate assault" on peaceful demonstrators in and around Tiananmen Square on June 4, 1989. Many other sanctions were also imposed on China by the 1989 statute and by President George Bush after Tiananmen, including:

- no defense sales;
- no satellites for China to launch for U.S. companies;
- no export licenses for "dual-use" civilian/military technologies;
- no export of Missile Technology Control Regime (MTCR) annex items;
- no export of crime control and detection equipment; and
- no international loans, except for projects which meet basic human needs.

Some sanctions have been eased, such as the Clinton administration change in policy on high-performance computers. However, sanctions on nuclear material, facilities, or components to China remained. Secretary of State Warren Christopher said on October 3, 1995 that it was not yet time to lift the remaining sanctions imposed after Tiananmen. To end the post-Tiananmen sanctions relating to the agreement of cooperation on nuclear export, the President must certify to Congress that:

- China has made progress on political reform (including Tibet) and on improving human rights; and
- China has provided "clear and unequivocal assurances" that it is not and will not assist any non-nuclear weapons states (NNWSs) in acquiring nuclear explosives, materials, or components.

Currently, disputes about exports thought to contribute to proliferation of weapons of mass destruction are:

- China's alleged sale of ring magnets for uranium enrichment by centrifuge to Pakistan; and
- China's alleged sale of MTCR-banned missiles or missile parts to Pakistan and Iran.

### **How Could an East Asian Regional Compact for Nuclear Cooperation Help Resolve This and Other Pertinent Nuclear Issues?**

The effectiveness of U.S. unilateral sanctions of nuclear export imposed on China while other countries (e.g., France) continue to sell these products to China has been debated fiercely. The loss of nuclear sales to China by Westinghouse, General Electric, ABB-Combustion engineering and many smaller companies that would supply material, facilities, or components, during the dwindling U.S. domestic market, is significant. The gain from such export sanction in inhibiting

Chinese proliferation, if it can be measured, is quite small. The sanctions imposed are more of a matter of principle rather than an effective means of influencing Chinese behavior.

China is an upcoming great power, regionally as well as globally. It should be responsible for its actions within its own sphere of influence. The best means of moderating Chinese behavior to conform to international norms is to include China in multilateral organizations. An East Asian Regional Compact could offer China the opportunity to lead, to regulate itself, and to influence other member states in nuclear cooperation for mutual benefit.

## APPENDIX 2: PEACEFUL USE OF PLUTONIUM IN JAPAN

### **Introduction**

Japan is an island nation poor in natural energy resources. It has to import almost all the energy needed to support its advanced economy. The pursuit of energy self-sufficiency has led not only to Japan's commitment to the development and use of nuclear energy, but also its plans for recycling nuclear fuel and the use of plutonium in breeder reactors. Many other East Asian countries (e.g., China/Taiwan, South Korea, Indonesia, and Thailand) are also making vigorous efforts to promote the use of nuclear energy to meet rapidly increasing demands for electricity. These demands are fanned by the phenomenal economic growth experienced in the region in the past decades and the continuing stride to improve the region's standard-of-living.

The end of the Cold War and the passage of the indefinite extension of the Non-Proliferation Treaty (NPT) brought high hope for nuclear arms reduction and concern for what to do with the separated plutonium from dismantled weapons. At this crossroads, plutonium is viewed on one hand as the energy bridge for economic prosperity, and on the other hand, as a target of proliferators and the culprit for global instability.

Therefore, it is not surprising that Japan's long-standing policy of basing its nuclear energy program on reprocessed plutonium would become the focus of debates between the United States and Japan.<sup>21</sup> The polarized viewpoints of these debates were centered on the dual aspects of nuclear energy and nuclear proliferation, with Japan steadfastly arguing the beneficial energy use of plutonium and the United States continuously discouraging fuel-reprocessing and the stockpiling of separated plutonium. With each side holding onto its argument, it is unlikely that the debate will come to any fruitful conclusion soon.

### **Background**

The debate on the dual aspects of nuclear technology between the United States and Japan has been long standing. The United States, alarmed by the 1974 Indian detonation of a nuclear device using technology and materials obtained under the name of peaceful purposes, changed its policy toward the use of plutonium in the nuclear fuel cycle. For Japan, whose concern is energy security, the salient event in 1974 was not the Indian explosion but the aftermath of the first Arab oil embargo.

When President Carter announced in April 1977 that the United States was going to defer civilian reprocessing and the use of plutonium in existing reactors, just when Japan was completing the final stage of its first pilot scale reprocessing plant at Tokai, the announcement brought considerable consternation in Japan. Because of the existing U.S.-Japan agreement for nuclear cooperation, the U.S. was asked to make a special exception for Japan, and Japan needed to ask for U.S. permission every time U.S.-origin fuel under Japanese custodianship was reprocessed. The exception created a disparity because Japan was allowed to do what the U.S. domestic industry was not able to do. And the permission was considered preferential and discriminatory because no such permission was granted to Japan's neighbor, South Korea, even after many requests.

The Tokai-reprocessing issue served to intensify the dispute between the United States and Japan on nuclear energy and nuclear proliferation. Although President Carter's policy on civilian reprocessing was rescinded later, the U.S. stance on no reprocessing was anchored on the prevention of nuclear proliferation. The current U.S. reprocessing policy, as stated in President Clinton's nonproliferation policy statement of September 1993, holds the position that it will neither engage in reprocessing nor encourage or discourage it in other nations, and will seek to eliminate where possible the accumulation of stockpiles of plutonium.

Japan, based on a long-term energy program with emphasis on the importance of the peaceful use of nuclear energy, enacted a plan for the recycling of nuclear fuel, including the use of plutonium in existing and advanced light-water reactors (LWRs), and in fast breeder reactors. In an attempt to dispel suspicions over its controversial plutonium-use programs, Japan has signed the NPT, accepted full-scope IAEA inspections, promoted openness and transparency of

the program, as well as imposed upon itself the rule of maintaining a supply-and-demand balance of plutonium.

The coolant leak incident that happened on December 8, 1995 in Japan's prototype fast-breeder reactor Monju amounted to the most serious setback to its plutonium-use program. According to projections, Japan's consumption of plutonium is supposed to reach 5 metric tonnes annually by 2010, including 600 kg by Monju and 700 kg by a yet-to-be-built demonstration breeder reactor. These figures are designed to match the corresponding amount of plutonium to be supplied by the existing Tokai reprocessing plant and the Rokkasho reprocessing plant, now under construction. If Monju is out of service for a prolonged period, that could result in an accumulation of excess plutonium, raising concerns for the protection of the plutonium in Japan and worry in other Asian countries about the prospect of Japan developing its weapons program.

To maintain a supply-and-demand balance of plutonium, Japan would have to increase the use of plutonium in existing LWRs. Since U.S.-origin fuel is involved and Japan's domestic capacity for mixed-oxide (MOx) fuel fabrication is not yet adequate, Japan requested U.S. consent to add the European MOx facilities to the list of fuel cycle facilities designated under the 1988 U.S.-Japan agreement for nuclear cooperation. Again, the request highlighted a disagreement between the U.S. Department of Energy (DOE) and the State Department over Japan's plutonium-use policy, creating an issue somewhat reminiscent of the Tokai-reprocessing conundrum of 1977.

### **How Could an East Asian Regional Compact Framework for Nuclear Cooperation Help in Resolving This and Other Pertinent Nuclear Issues?**

A regional compact framework for nuclear cooperation in East Asia could promote economic cooperation, nuclear-material safeguards and transparency, the safe operation of nuclear facilities, and the safe disposal of nuclear waste material. The coordinated management and reciprocal inspection of plutonium stocks held by all member states, including Japan, would be an important aspect of such a regional framework. If Chinese and Korean personnel could monitor Japan's plutonium stock and vice versa, the concern that plutonium could be misused for weapons activities in Japan can be minimized.

### APPENDIX 3: SOUTH KOREA'S RESEARCH PROGRAM IN DUPIC

Spent Pressurized Water Reactor (PWR) fuel can be used directly in CANDU reactors without the need for conventional wet chemical reprocessing (such as the PUREX process) or re-enrichment. Atomic Energy of Canada Limited (AECL), the Korean Atomic Energy Research Institute (KAERI) and the United States Department of Energy (U.S. DOE) are involved in a joint program to develop a process for the Direct Use of Spent PWR fuel in CANDU reactors (DUPIC). This involves reconfiguring the spent PWR fuel into a form that can be used in a CANDU reactor without using wet reprocessing technology. The spent PWR fuel is declassified and refabricated by an oxidation-reduction dry process OREOX.<sup>22</sup> By the nature of OREOX, the volatile and semi-volatile fission products are removed and all the fuel materials and solid fission products are directly reused as DUPIC fuel. The inclusion of the highly radioactive fission product in the DUPIC fuel render the requirement for remote or automated operation for OREOX. It also provides a radiation barrier to enhance proliferation-resistance to DUPIC fuel. The fissile content of the reference DUPIC fuel is 1.5 wt%, more than twice that of natural uranium fuel.

AECL has already demonstrated many of the critical features of the advanced fuel cycle. DUPIC fuel bundles are simple and therefore relatively easy to construct using remote/automatic handling technology. This means that the advanced fuel cycle and in particular the DUPIC fuel cycle, is considered feasible by South Koreans.

The proliferation resistance of DUPIC technology should not focus only on the OREOX process alone. The examination should involve the entire DUPIC fuel cycle including the operation of the CANDU reactor. A regular CANDU reactor employs a continuous refueling of natural uranium in pressurized fuel channels. It is easier to conceal dedicated fuel channels for the production of desired weapons nuclear material in a CANDU than in a standard LWR. Dedicated fuel bundles could then be recycled as "deflected fuel" and processed through the remotely operated OREOX for the recovery of clandestine weapons-usable material. Stringent monitoring requirements are deemed necessary for a DUPIC fuel cycle.

#### **How Could an East Asian Regional Compact Framework for Nuclear Cooperation Help in Resolving This and Other Pertinent Nuclear Issues?**

The two-tier fuel-reprocessing policy imposed by the United States on the U.S.-origin fuel discharged by reactors operated in South Korea is deemed problematic. The U.S. has so far denied any attempt by South Korea to reprocess U.S.-origin fuel, but has allowed Japan to do so. If fuel-reprocessing means the conventional, aqueous PUREX process, the South Korean government could request exemption for such restriction on the ground that OREOX is not fuel-reprocessing since it is a dry process and it does not completely separate the fission products from the fuel material.

An East Asian Regional Compact Framework for nuclear cooperation could provide the coordinated management and reciprocal inspection of nuclear material held by all member states. If South Korea could open its advanced fuel cycle facilities to Chinese and Japanese inspection personnel in addition to IAEA inspectors, proliferation concerns about its DUPIC fuel cycle could be minimized.

## APPENDIX 4: TAIWAN'S SECURITY CONCERN AND ITS SPENT FUEL MANAGEMENT PROBLEM

Taiwan currently has an inventory of spent nuclear fuel of 1,850 MgHM discharged from its nuclear reactors and stored in wet storage pools at reactor plant sites. Taipower has re-racked the on-site wet storage pools for the four older nuclear units. With increased capacity plus spent-fuel shuffling among the six operating units, the average capacity for discharged fuel could be adequate beyond 2000. However, Taiwan is a densely populated island and most likely would not be able to locate a suitable site for permanent spent fuel disposal. Thus, Taiwan is interested in discussions with China, Russia, and the U.S. (at the Marshall Islands) about a possible spent fuel storage/disposal agreement.

Taiwan has left its back end nuclear policy open and has not decided whether to reprocess or directly dispose spent fuel. Taiwan had attempted in the late 1970s to develop fuel cycle technology including reprocessing, but had to give up the effort because of immense pressure from the United States.

Current events at the Taiwan Strait triggered by a "private" visit of Taiwan's President to Cornell University in the U.S. heightened Taiwan's security problem. China's missile tests and naval maneuvers off Taiwan in March 1996 were confronted by the U.S. carrier fleets conducting surveillance in international waters off the test area. The crisis passed when Chinese military exercises ended without any incidents. But Taiwan's desire to expand its international profile continues. In August 1996, Taiwan's Vice President privately visited Ukraine, a former Soviet Republic which still holds a significant amount of the Soviet nuclear weapons stockpile and nuclear weapons knowledge. A Japanese newspaper reported in 1996 that four Taiwan Air Force pilots tested Sukhoi SU-27 fighter jets in Ukraine to learn the capabilities of the fighters used by China.<sup>23</sup>

### **How Could an East Asian Regional Compact Framework for Nuclear Cooperation Help in Resolving This and Other Pertinent Nuclear Issues?**

Taiwan's security dilemma and the presence of a large inventory of fissile-containing spent fuel are sources of concerns for the region's stability. An East Asian regional compact framework could provide members with regional spent fuel storage facilities and a waste repository. Suitable host countries for the East Asian region could be China or the Russian Far East. Spent fuel generated in Taiwan could be transported to the host country(ies) for interim storage or permanent disposal, eliminating the concern that such spent fuel could be overtly or covertly reprocessed for the acquisition of fissile material.



## APPENDIX 5: THE U.S.-DPRK AGREED FRAMEWORK

The Korean Peninsula Energy Development Organization (KEDO), founded on March 9, 1995, is the international organization established to implement most of the "Agreed Framework" signed by the United States and the Democratic People's Republic of Korea (DPRK; North Korea) on October 21, 1994. The Agreed Framework addressed international concerns about clandestine nuclear activities in the DPRK, and if implemented, will ultimately lead to the complete dismantlement of those aspects of the DPRK's nuclear program, including reprocessing-related facilities and the graphite-moderated reactors.

The U.S.-DPRK Agreed Framework called for the DPRK to:

- freeze and eventually dismantle its graphite-moderated reactors (dismantlement will be completed upon the completion of a LWR project);
- seal, cease activities at, and eventually dismantle all reprocessing-related facilities (dismantlement will be completed upon the completion of the LWR project);
- cooperate in finding a safe method to store existing spent fuel from the DPRK's 5 MWe experimental reactor and to dispose of such fuel in a safe manner that does not involve reprocessing in the DPRK;
- allow the IAEA to monitor the aforementioned freeze and to resume ad hoc and routine inspections of facilities not subject to the freeze upon conclusion of a Supply Agreement for the LWR project (such Supply Agreement between KEDO and DPRK was signed in December 15, 1995);
- come into full compliance with the DPRK-IAEA safeguards agreement upon completion of a significant portion of the LWR project;
- remain a party to the Nuclear Non-Proliferation Treaty (NPT);
- engage in North-South dialogue, and take consistent steps to implement the North-South Joint Declaration on the Denuclearization of the Korean Peninsula.

In exchange for implementing its commitments under the Agreed Framework, the DPRK will receive:

- two light-water reactors (LWRs), on a turnkey basis, with a total generating capacity of approximately 2,000 MWe. KEDO will develop a delivery schedule for the LWR project aimed at achieving a completion date of 2003;
- 150,000 tons of heavy-fuel oil for heating and electricity production by October 1995 and 500,000 tons annually thereafter until the start of full power operation of the first LWR;
- formal assurances from the U.S. against the threat or use of nuclear weapons.

In addition to the above, the Agreed Framework called for the U.S. and the DPRK to:

- reduce barriers to trade and investment, including restrictions on telecommunications services and financial transactions;
- open a liaison office in each other's capital;
- upgrade bilateral relations to the ambassadorial level following progress on issues of concern to each side.

KEDO is currently supported financially by 12 countries, although much of KEDO's costs are covered by South Korea, the U.S. and Japan, including all administrative costs. South Korea and Japan will finance a major portion of the LWR project, while the U.S. will contribute to the cost of heavy fuel oil and the safe storage of the DPRK's spent fuel. Since its inception, KEDO has been in need of funding for the provision of heavy fuel oil. And since the first few shipments of heavy fuel oil, DPRK was caught in diverting the fuel oil to other uses besides providing heat to its people. The DPRK threatened to restart its indigenous reactors and reprocessing facilities if the

disputes over the U.S. funding and oil diversion were not resolved in its favor. In addition, the IAEA was still seeking to verify the accuracy and completeness of DPRK's inventory of nuclear materials, to install monitoring equipment in the Yongbyon reprocessing facility, and to examine the fuel rods from the 5 MWe experimental reactor.

**How Could an East Asian Regional Compact Framework for Nuclear Cooperation Help in Resolving This and Other Pertinent Nuclear Issues?**

The four main parties of KEDO, i.e., the U.S., DPRK, South Korea, and Japan, are also members of the proposed East Asian regional compact. KEDO essentially is a multilateral organization set up to deal with a specific regional problem. KEDO should extend its membership to include China and Russia because both countries are DPRK's neighbors and allies (former or present), both have significant interest in the region's security and stability, and both could be suitable host countries to receive the DPRK's 8,000 spent fuel rods.

## APPENDIX 6: RUSSIAN'S NUCLEAR WASTES IN THE FAR EAST

In early 1993, Russia admitted that the former Soviet Union had dumped civilian and military radioactive wastes for decades in the Sea of Japan (the East Sea). The total quantity of radioactive materials involved is listed below:

Location	Activity at time of dumping (Ci)	
	<i>Liquid Effluent</i>	Solid Waste
Sea of Japan (East Sea) - at 6 sites	11,985.00	7,000.00
Sea of Okhotsk - at 1 site	0.10	
East coast of Kamchatka - at 2 sites	350.00	

The dumping of radioactive waste in the Sea of Japan (East Sea) is one of the most important sources of marine pollution. Revelations of past Soviet dumping highlighted the possibility of additional uncontrolled radioactive pollution arising from Russian's military and civilian reactors operating in the Far East.

Russia lacks the financial resources and on-shore facilities required to manage the radioactive legacy of the Cold War. Among the most urgent tasks is the removal of nuclear reactors and spent fuel from decommissioned nuclear-powered submarines and icebreakers, for safe on-shore storage and disposal. To curtail Russian radioactive waste dumping at sea and to prevent the unforeseen accident of a decommissioned nuclear submarine sinking with a reactor core aboard, interim storage facilities and an eventual permanent repository must be constructed in Russian's Far East territory. The facilities are needed in the Far East because vast amounts of radioactive material (wastes and spent fuel) have already accumulated in the region, the Russian rail system is not reliable for transport of radioactive material across Siberia, and the Mayak facility is limited in its capacity to reprocess naval fuel.

Russia is in need of funding and technical knowledge for decommissioning and decontamination of nuclear vessels. Other countries in the region have complementary capabilities. Japan, for example, has significant experience in decommissioning its former nuclear-powered ships and also has provided Russia support in constructing on-shore LLW storage facilities.

### **How Could an East Asian Regional Compact Framework for Nuclear Cooperation Help in Resolving This and Other Pertinent Nuclear Issues?**

Russia's Far East is a scarcely-populated region. There should be ample land area for suitable sites in the region for the construction of a permanent spent fuel or HLW repository. Russia would have to construct on-shore storage facilities in the Far East region for its radioactive wastes and spent nuclear fuel generated by its Pacific nuclear fleet. If it would consider accepting radioactive wastes and spent fuel generated by its neighboring states, such as from Taiwan, South Korea, and Japan, financial assistance could be provided by these states. Also, since Russia is already a nuclear weapons state, it politically could be a host country providing waste storage and disposal services. An East Asian Regional Compact Framework could facilitate such storage/disposal arrangements currently needed by states in the region.

## APPENDIX 7: URANIUM ENRICHMENT AND THE FRONT END NUCLEAR FUEL CYCLE POLICIES

### **Background**

The global uranium enrichment market is undergoing a number of significant changes. These changes, including the privatization of the United States Enrichment Corporation (USEC), the blending and sale of U.S. and Russian high-enriched uranium (HEU), and the expanded use of new enrichment technologies (i.e., centrifuge and laser isotope separation), not only could profoundly affect the supply of future enrichment services, but also have significant implications about the nonproliferation aspect of nuclear fuel cycle policies.

The privatization of the world's largest uranium-enrichment supplier, USEC, would significantly change the primary supply picture, although the process is moving slower than originally projected. When privatization occurs, USEC's future business strategy would depend on the business interests and objectives of its new owners, which are to maintain and increase profitability. This strategy is very different from that of a government-owned U.S. enrichment enterprise when the supply decisions were made primarily to conform to U.S. non-proliferation objectives. Before the formation of USEC, the U.S. Department of Energy (DOE) owned and operated the three gaseous diffusion plants (GDPs; in Portsmouth, Ohio; Paducah, Kentucky; and the already shutdown K-25 in Oak Ridge, Tennessee) and provided enriched-uranium fuel to U.S. domestic utilities and most of the foreign-reactor operators who conformed to U.S. non-proliferation policy. The U.S. could dictate the back end nuclear fuel cycle policies of these foreign reactor operators by demanding consent rights of U.S.-origin fuel (and to that matter, any non-U.S.-origin fuel which resides in the reactor cores at the same time with U.S.-origin fuel). For example, DOE could grant permission to Japan's utilities to reprocess spent fuel produced from U.S.-origin fuel, but continuously discourage South Korea and Taiwan from pursuing fuel-reprocessing. As a privately owned company, USEC's focus would be primarily based on business and may not have the same non-proliferation objectives as those of DOE.

Over the next decade, the blending and sale of U.S. and Russian HEU could profoundly change the uranium enrichment market. Between the two countries' blending operation, it is likely that a quarter of the world demand for enrichment services could be met. The LEU from HEU-blending would most likely be used domestically, which in turn, would add pressure to the already competitive market serving the foreign reactor operators. It is expected that most of the demand for enrichment services would come from Asia, a region which is already competitive among non-U.S. enrichment suppliers, mainly, Tenex from Russia, Cogema and Urenco from France, and UIC.

New enrichment technologies, like the Atomic Vapor Laser Isotope Separation (AVLIS) and advanced centrifuges, that reduce power consumption and production costs will be very influential to the future uranium enrichment market. No supplier can afford to rely on gaseous diffusion or older centrifuge technology for the long term. Whether USEC is privatized, or remains as a government corporation, it simply could not continuously operate two gaseous diffusion plants (at Portsmouth and Paducah) and expect to make a profit. It is expected that USEC would retire one or both of the U.S. GDPs and deploy AVLIS over the next two decades. Japan and France also have on-going AVLIS development programs. In addition, Russia, Urenco, and Japan all have proven operating centrifuge plants and have been successful at gradually increasing the separation efficiency and reducing the costs of their technology. The expanded use of these new technologies and the competitive market would make uranium enrichment a global commodity tied more to business principles and less to political constraints.

### **How Would a Regional Compact Help?**

A regional compact framework could help in securing the supply of uranium enrichment to current nuclear programs in East Asia. It could assure a stable, reliable, and economical supply of nuclear fuel from global suppliers to all member states and provide a coordinated management and reciprocal inspection of nuclear material in the region. Such an assurance of fuel supply could help alleviate the temptation of a country to pursue independent "nuclear-fuel self-sufficient

policy." In addition, a regional compact framework could provide a forum for constructive dialogues and promote confidence-building measures to ensure that nuclear activities engaged in the region would be consistent with the Non-Proliferation Treaty (NPT) and International Atomic Energy Agency (IAEA) statutes.

With the U.S. seemingly losing its market share in providing future enrichment services and having less control over policies of new emerging nuclear programs, it is prudent for the U.S. to consider a regional compact alternative to ensure that its nuclear objectives can be realized.

## APPENDIX 8: SUMMARY OF THE SPENT FUEL MANAGEMENT PROGRAMS AND BACK END NUCLEAR FUEL CYCLE POLICIES IN EAST ASIA

The spent nuclear fuel management programs in East Asia (China, Japan, North and South Korea, Taiwan, and the Russian Far East) are described below:

### **China**

The amount of spent nuclear fuel accumulated in China's nuclear power reactors is approximately 165 MgHM as of 1996. Its civilian nuclear power plants (the 300 MWe Qinshan, and the 2 units of 900 MWe each at Daya Bay) would generate 65 MgHM of spent fuel per year. Based on a nuclear generating capacity of 2.1 GWe by the year 2000, there will be a total of 425 MgHM of spent fuel accumulated in China's nuclear program.

The civilian nuclear spent fuel is stored in wet storage pools at reactor plant site for at least 5 years in order to reduce its radioactivity.<sup>24</sup> This interim storage period would most likely be extended to 10 years or more because the reactors' owners would like to put off delivery of spent fuel to postpone payment to the fuel reprocessor. The current plan is to transfer spent fuel after a 5 to 10 year at-reactor storage to a central wet storage facility at Lanzhou, Gansu Province.<sup>25</sup> Work on the wet storage facilities has begun at the Lanzhou site. It is to be constructed and completed in three phases, with storage capacities of 550, 500 and 1050 MgHM for each phase respectively.

China's nuclear back end policy is to pursue spent-fuel reprocessing and recycling of the recovered uranium and plutonium. A pilot fuel reprocessing facility, with throughput of 25 MgHM per year is now under construction at Lanzhou and is expected to be operable by 2000. A commercial-size reprocessing plant with a capacity of 400 MgHM per year is to be built, most likely at Lanzhou, with completion planned for around 2020.

China's current nuclear generating capacity is too small to support a commercial-size reprocessing facility. It is anticipated that the total capacity of China's nuclear power plants, almost all Pressurized Light-Water Reactors (PWRs) except a few CANDU reactors, will come to 20 GWe by 2010. Assuming that China's nuclear capacity is to be increased at a rate of 2 GWe (equivalent to two 1000 MWe nuclear power plants) a year starting from 2001, the annual discharge of spent fuel could reach an amount of 600 MgHM or more depending on the CANDU reactor share, and the total amount of spent fuel accumulated by 2010 would be more than 3,000 MgHM.

China's nuclear power plants (existing and planned) are mostly located on the southern and southeastern coastal areas, while the central spent fuel storage facilities and the future fuel-reprocessing plants are located in the northwestern province of Gansu. Long-distance transport of spent fuel by sea and by rail is required. A contract of taking over the spent fuel discharged from the Daya Bay nuclear power plants was negotiated between the plant owner (a Sino-Hong Kong joint venture) and China National Nuclear Corporation (CNNC), for a total amount of 800-1000 MgHM (equals to 20 years of discharge from the reactors covered by the joint-venture ownership period). Since there is no direct rail access to the Daya Bay plant site, a combined transport option by both sea and rail was adopted, using a large loading casks in a planned schedule of two round trips per year.

A sea route of about 3000 nautical miles from the Daya Bay site and along the South China Sea coast is planned.<sup>26</sup> Two ports, Shanhaiquan or Lanshan in the middle of China's eastern coast, could possibly be facilitated with a purpose-built marine terminal and equipped with a rail-mounted cantilever crane for unloading the spent fuel cask off the ship and transferring it onto the connecting rail line. The rail transport distance between the marine terminal at the port and the central storage facilities at Lanzhou is about 3000 km.

China's emphasis during this early stage of developing its civilian nuclear program would most likely be on nuclear safety and capacity expansion. The back end spent fuel management and disposal would not become a major issue until around 2010 when nuclear capacity has expanded significantly and the spent fuel has accumulated to a significant quantity. However,

China could play an important role to help resolve some of the most critical nuclear issues currently facing its regional neighbors, mainly, to provide interim storage facilities (similar to those being constructed at Lanzhou) for spent nuclear fuel generated by its regional neighbors. China had offered the European utilities (in Belgium and Germany) in the mid 1980s the service of managing their spent fuel for a fee of U.S.\$1500 per kgU (1984\$). It would be interesting to see whether China would again be willing to offer a similar type of service (for a fixed fee and a defined duration) to utilities in East Asia.

In addition, China is a declared nuclear-weapons state with an established nuclear material production program. China's nuclear weapons program is relatively small compared to those in the U. S. and Russia. Nevertheless, its program will produce significant amounts of nuclear materials which require interim storage and ultimate disposition. How would China deal with the nuclear weapons material and how would this impact the management of its civilian nuclear material are interesting questions.

## **Japan**

The amount of spent nuclear fuel accumulated in Japan's nuclear power reactors is approximately 13,000 MgHM as of 1996. Based on the current nuclear capacity of 41 GWe, its civilian nuclear power plants (50 units) would generate approximately 1000 MgHM of spent fuel per year. By 2010, Japan's nuclear power projection is expected to reach 72 GWe, although it is doubtful that this target can be met because of the difficulty in obtaining adequate siting for new capacity.

Spent fuel discharged from reactors are stored in wet storage pools at reactor plant sites. A total of 7,100 MgHM of that inventory are under contract with the UK and French reprocessors. The rest is stored and destined for the Rokkasho reprocessing plant, an 800 MgHM/ year plant expected to be in operation by 2000. High density racks employing neutron-poison design had been incorporated in most of the wet storage pools at reactor plant sites. The total spent fuel storage capacities in Japan's nuclear program is 14,300 MgHM at current reactor plant sites plus 4,800 MgHM now in expansion.

Japanese utilities have serious concerns about the extremely high capital cost of constructing and completing the Rokkasho reprocessing facility. Should there be further delay in Rokkasho's startup schedule, the total amount of spent fuel accumulated in the nuclear program could reach a point that existing reactor plants may have to shut down because of lack of on-site storage space. The cooling pond which is co-located at the Rokkasho facility could be used for central storage. However, the pond's storage capacity is limited to 3000 MgHM, approximately equal to three years of annual discharge from Japan's nuclear power plants.

Assuming that the Rokkasho plant could be started by 2000 and Japan's total nuclear capacity could reach 72 GWe by 2010, additional storage capacities would be required after 2010. In addition, there is a legal problem associated with the spent fuel management problem in Japan. The relevant Japanese law requires the reactor owner to specify where and how the spent fuel will be managed before the reactor is granted a license to operate. This is the major reason why Japanese utilities went ahead with UK/French reprocessing contracts much before their actual needs develop. Similarly, it will be necessary very soon for those utilities filing applications for new nuclear plants to specify where spent fuel from these plants in 10 or 15 years time will be stored or processed.

Recognizing such potential difficulty in managing Japan's vast amount of spent fuel, Professor Suzuki Atsuyuki of Tokyo University in his presentation to the Energy Workshop of the Northeast Asia Cooperation Dialogue V meeting in Seoul, Korea, proposed an international collaboration of nuclear spent fuel management in East Asia. His proposal was to build and operate international facilities in East Asia for intermediate storage of spent fuel arising from nuclear power plants and for underground research on geologic disposal.

## **South Korea**

The amount of spent nuclear fuel accumulated in South Korea's nuclear power reactors is approximately 3,000 MgHM as of 1996. Based on the current nuclear capacity of 8.2 GWe, its civilian nuclear power plants (9 PWRs and 1 CANDU reactor) would generate approximately 250

MgHM of spent fuel per year. South Korean's nuclear capacity is expanding rapidly and its nuclear power projection by 2010 is expected to reach 26 GWe. The total amount of spent fuel accumulated by then would be about 12,000 MgHM.

Spent fuel discharged from reactors are stored in wet storage pools at reactor plant sites. Some of the pools were renovated with high density racks to increase storage capacity. For the Kori site (which houses 4 reactor units), after re-racking the wet storage pool with high-density racks, the average storage capacity for discharged spent fuel from all four units will reach its limits by 1997. An interim storage facility for spent fuel will be built by 2001, an away-from-reactor wet storage pool with a storage capacity of 3000 MgHM is being considered. However, any of these plans could not have solved Korea's immediate need for additional storage space, and shuffling of spent fuel to other sites would be required to prevent the shutdown of any Kori units. The South Koreans understand that spent-fuel shuffling among at-reactor sites could only help the management problem temporarily. They must therefore find alternative means to store, or otherwise dispose of, the spent fuel accumulated in their nuclear power program. However, it is also becoming increasingly difficult to acquire extra sites for storing spent fuel and radioactive wastes, let alone disposing of them, because of widespread resistance among local population. The recent plan to build a special storage facility on Kulop Island off Incheon met with violent popular opposition and finally the plan was forced to be canceled.

Fuel reprocessing could be a possible alternative, although a few hurdles would have to be overcome. First is the consent from the United States on reprocessing spent fuel of U.S. origin. South Korea has not provoked the U.S. by seeking reprocessing capability, although it has sought reprocessing-related technology--so far without success--from Canada and the U.S. Second is the consideration of meeting its commitment when it signed the Peninsula Denuclearization Declaration in 1992 with North Korea not to build indigenous reprocessing plants in the Korean Peninsula (However, IAEA's inspections of North Korea's nuclear facilities at Yongbyon in 1992 revealed North Korea's continued expansion of the clandestine reprocessing plant, a clear violation of its NPT and Joint Declaration obligations. This led to South Korea's shelving the bilateral declaration on the de-nuclearization of the Korean Peninsula). South Korea could send its spent fuel abroad (for example, to UK, France, and even Japan after 2005) for reprocessing, and previously, it held talks with Russia over reprocessing its spent nuclear fuel at an incomplete facility (RT-2) at Krasnoyarsk in Siberia. Third is the success of South Korea's own interest in the research project with AECL and the U.S. on DUPIC, a process of direct-use of PWR spent fuel in CANDU reactors.

## **Taiwan**

The amount of spent nuclear fuel accumulated in Taiwan's nuclear power reactors is approximately 1,800 MgHM as of 1996. Based on the current nuclear capacity of 4.9 GWe, its civilian nuclear power plants (4 BWRs and 2 PWRs) would generate approximately 150 MgHM of spent fuel per year. Because of increased domestic opposition to nuclear power, Taiwan's nuclear program is expected to have a modest gain over the next decade with its nuclear power projection by 2010 to be about 8 GWe. The total amount of spent fuel accumulated by then would be about 4,000 MgHM.

Taipower has re-racked the on-site wet storage pools for the four older nuclear units and the two newer units are equipped with high density storage racks. (The two newer PWR units' wet storage pool were designed to store the lifetime discharge of spent fuel). With increased capacity plus spent-fuel shuffling among the six operating units, the average storage capacity for discharged fuel should be adequate until the early years of the next century. However, Taiwan is an island densely populated, and most likely would not be able to locate suitable sites for an interim spent fuel storage facility or for permanent disposal. Thus, Taiwan is interested in discussion with China, Russia, and the U.S. (for storage at the Marshall Island) about a possible spent fuel storage disposal agreement. Without such an agreement, it is feared that some of the operating nuclear power plants would have to be shut down because of the lack of storage space at reactor sites and the immense opposition from the public for building an interim storage facility near its community.

Taiwan has left its back end nuclear policy open and has not decided whether to reprocess or directly dispose spent fuel. Taiwan attempted in the late 1970s to develop fuel cycle



technology including reprocessing, but had to give up the effort because of intense pressure from the United States.

### **North Korea**

North Korea has about 8000 spent fuel rods discharged from and currently stored in water pools at the 5 MWe Yongbyon nuclear reactor plant. Since 1995, DOE has been assisting North Korea in recanning these spent fuel rods in stainless canisters. After recanning, the spent fuel canisters would be placed back into the wet storage pool pending for future disposition. During the early phase of negotiation for the now-signed "Agreed Framework," these spent fuel rods were supposed to be shipped to a third country. However, North Korea is currently using them as a guarantee that the two LWRs must be constructed before the fuel rods leave North Korea. Since then, the list of possible third-country recipients of these fuel rods has significantly shrunk (North Korea was not willing to send these rods to Russia, South Korea, or Japan. China appears to be unwilling to accept them, and transport to France or UK would be too costly because of the distance). The North Korean spent fuel rods may have to be brought back to the U.S. for storage or further processing.

The U.S. is currently accepting the return of spent fuel from research reactors in foreign countries under DOE's RETR program. These foreign research reactors were originally fueled with high-enriched fuel provided by DOE. Some of these returned fuel received at the Savannah River Site in South Carolina may require reprocessing because these fuel rods are enclosed with material that would not be corrosive-resistant enough or suitable for long-term storage. Should the U.S. take custodianship of North Korean spent fuel rods, questions regarding the ownership of these rods and the recovered material, in case of reprocessing, as well as safeguards and security during transport and safety during interim storage and processing are needed to be resolved.

There is great interest to locate a host country in East Asia capable of and willing to accept these spent fuel rods from North Korea. For reasons of economics and safety, much of the routine handling and shipment of these rods should be carried out on a regional basis to minimize costs and risks (safety and security) associated with the shipments.

### **Russian Far East**

The Russian Far East is home to Russia's Pacific nuclear fleet, which consists of about one-third of Russia's active fleet of nuclear-powered submarines, icebreakers, and surface supply ships. A somewhat larger number of nuclear-powered vessels make up the inactive fleet. Much of the inactive fleet consists of submarines awaiting dismantlement and disposal of their nuclear fuel, reactor compartments, and radioactive wastes. The dismantling of the inactive fleet poses serious threat of nuclear contamination to the regional environment from accidents or release of radioactivity.

Russia lacks the financial resources and on-shore facilities required to manage the radioactive legacy of the Cold War. Among the most urgent tasks is the removal of nuclear reactors and spent fuel from decommissioned nuclear-powered submarines and icebreakers, for safe on-shore storage and disposal. To curtail Russian radioactive waste dumping at sea and to prevent an unforeseen accident of a decommissioned nuclear submarine sinking with its reactor core aboard, interim storage facilities and eventual permanent repository must be constructed in the Russian Far East. The facilities are needed in the Far East because of the vast amounts of radioactive material (wastes and spent fuel) already accumulated in the region, the Russian rail system is not reliable for transport of radioactive material across Siberia, and the Mayak facility is limited in its capacity to reprocess naval fuel.

### **Summary**

The spent fuel management programs and the back end nuclear fuel cycle policies in East Asian countries are summarized in Table 4.

**Table 4-4: East Asian Spent Fuel Management Programs**

CHINA	
Spent fuel quantity: Accumulated in 1995 Annual discharge Accumulated by 2000	100 MgHM -65 MgHM (based on the current nuclear capacity of 2100 MWe) -425 MgHM
Spent fuel storage:	Wet storage at reactor plant sites for 10 years, then transfer to central wet storage. Central wet storage is co-located with the planned fuel reprocessing facility in the northwest region. Work has started on the wet storage facilities which are constructed in 3 phases, storage capacities are: 550 MgHM, 500 MgHM, and 1050 MgHM.
Back end policy:	Fuel reprocessing. A reprocessing facility was built on the Lanzhou site (northwest region) in 1970. A new 25 tU/y pilot plant now under construction there is expected to be in operation by 2000. A commercial reprocessing plant with a capacity of 400 tU/y is to be built in Gansu Province, with completion planned for around 2015. HLW will be vitrified, presumably using the PAMELA technology, the vitrified wastes will be stored for 50 years, then disposed in a deep geologic repository. The program for a repository for HLW contains 4 phases: 1985 to 1995--technical preparation 1995 to 2010--geologic studies 2010 to 2025--construction of underground laboratory and site experiments 2025 to 2040--repository construction prospective repository sites for HLW will be at Chinese nuclear test site (Lop Nur, Gobi desert) or Taiyuan in Shanxi Province.
Remark:	China had offered the European utilities in the '80 the service of managing their spent nuclear fuel, for a fee of U.S.\$1500 per kgHM. It would be interested to see whether China would again be willing to offer a similar type of service to utilities in countries of the East Asia region.
JAPAN	
Spent fuel quantity: Accumulated in 1995 Annual discharge Accumulated by 2000	12,800 MgHM -800 - 1000 MgHM (based on the current nuclear capacity of 39,000 MWe) 16,800 - 17,800 MgHM
Spent fuel storage:	Spent fuels discharged from reactors are stored in wet storage pools at reactor plant sites. Spent fuels transported from nuclear power plants to reprocessing are cooled for one year. Upon receipt at the reprocessing facility, spent fuels are kept for four years in the wet storage pool. The pool's storage capacity is 3000 MgHM, approximately three years of annual discharge.
Back end policy:	Fuel reprocessing. A reprocessing facility is now operating at Tokai-mura. A commercial reprocessing plant with a capacity of 800 tU/y is being constructed at Rokkasho site, expected to start operating after 2000. Decision for a second commercial plant will be made around 2010. Japan will rely on BNFL of the UK and Cogema of France for reprocessing

	<p>Plutonium, reprocessed from spent fuel from Japanese nuclear plants by BNFL and Cogema is to be fabricated into MOx fuel and recycled in Japanese reactors.</p> <p>4 Mg of fissile plutonium to be used by the fast reactor Monju and the ATR Fugen by 2000.</p> <p>From 2000 to 2010, the estimated fissile plutonium need is 35-45 Mg. About 30 Mg will be supplied by the overseas reprocessing plants and the balance from the Tokai and Rokkasho plants.</p> <p>The storage facility for high-level vitrified waste returning from abroad was completed in Jan. 1995.</p> <p>On April 26, 1995 the first cask, containing 28 canisters of vitrified HLW, arrived from France.</p> <p>A geologic repository program is planned for 2030.</p>
Remark:	<p>Japan AEC has recently revised the country's plan for future nuclear development. The revised program allows some slowing down of nuclear development, notably in fuel reprocessing and plutonium use. This may result in surplus of separated plutonium. Japan would face a problem of whether to store the separated plutonium at overseas reprocessing plants and pay for the high cost of storage, or to ship the plutonium back to Japan and risk of diversion and theft. (Japan's constitutional ban on using heavy-armed guards is problematic in terms of safeguarding and securing the separated plutonium.)</p>
<b>SOUTH KOREA</b>	
Spent fuel quantity: Accumulated in 1995 Annual discharge Accumulated by 2000	<p>2,600 MgHM</p> <p>250 MgHM (based on the current nuclear capacity of 8200 MWe)</p> <p>3,850 MgHM</p>
Spent fuel storage:	<p>Spent fuels discharged from reactors are stored in wet storage pools at reactor plant sites. For the Kori site (which has 4 reactor units), after re-racking the wet storage pool with high-density racks, the average storage capacity for discharged spent fuel of all four units will reach its limit by 1997. Shuffling of spent fuel from the Kori units to others may be required. An interim storage facility for spent fuel (ISFSF) will be built by 2001, an away-from-reactor wet storage pool is being considered, which will have a storage capacity of 3000 MgHM.</p>
Back end policy:	<p>South Korea has not decided whether to reprocess or directly disposal of the spent fuel. However, S. Korea is currently conducting research with AECL of Canada on a DUPIC fuel cycle (Direct Use of spent PWR fuel In Candu): to process the spent fuel from PWRs, convert and fabricate the product into Candu fuel bundles (with or without the fission products), and recycle into the Candu reactor.</p> <p>The goal of the DUPIC fuel cycle is to generate less HLW on the basis of per unit energy produced.</p> <p>The non-proliferation aspect of the DUPIC fuel cycle warrants further evaluation.</p> <p>South Korea currently has no plan for a radioactive waste repository after its plan to use the island of Kurop-do to be the country's first repository was opposed by the local government.</p>
Remark:	<p>The DUPIC fuel cycle pursued by South Korea would present a challenge to the U.S. Non-proliferation policy. The South Korean</p>

	would request the permission from the USDOE to (re)process the U.S.-origin fuel using the DUPIC technology.
TAIWAN	
Spent fuel quantity: Accumulated in 1995 Annual discharge Accumulated by 2000	1,700 MgHM 150 MgHM (based on the current nuclear capacity of 4900 MWe) 2,450 MgHM
Spent fuel storage:	Spent fuels discharged from reactors are stored in wet storage pools at reactor plant sites. Taipower had re-racked the on-site wet spent fuel storage pools for the four older units. With increase capacity plus spent-fuel shuffling among storage pools of the six operating units, the average storage capacity for discharged spent fuel would be adequate beyond 2000. Taipower has initiated in 1993 the preparatory work for a regional repository to store its spent fuel. Discussions with China, Russia, and the U.S. Marshall Island for a possible ISFSF site is ongoing, but so far no deal has been made.
Back end policy:	Taiwan has not decided whether to reprocess or directly disposal of the spent fuel. Taiwan's present nuclear policy is to use nuclear energy for electricity generation. Taiwan presently has not pursued fuel-cycle technology (discounting the failed attempt in the late '70). Taiwan would face a dilemma with its spent fuels (same for the radioactive wastes) if it could not find a satisfactory repository location within its domain, could not send the spent fuel to its regional neighbors, and could not send the spent U.S.-origin fuel to the U.S. repository for disposal.
Remark:	Taiwan is an island densely populated, and most likely would not be able to locate a suitable site for spent fuel disposal. If shipping the spent U.S.-origin fuel back to the U.S. or anywhere is not likely Taiwan may request the U.S. permission's for fuel-reprocessing in Europe (France and
NORTH KOREA	
Spent fuel quantity: Accumulated in 1995	8,000 spent fuel rods at the 5 MWe Yongbyon nuclear reactor plant site The plant is currently shut-down.
Spent fuel storage:	The 8,000 spent fuel rods are stored in cooling ponds since mid-1994. Since 1995, the fuel rods have been placed in stainless steel canisters. The original plan was to ship them out of North Korea, however, North Korea has demanded a guarantee that the LWRs will be built before the fuel rods could leave. Russia, Japan, and South Korea are not now able to receive the fuel rods, and China appears unwilling to accept them, and transport to France or UK would be too costly. The North Korea's spent fuel rods may need to be brought to the U.S. for reprocessing.
Back end policy:	North Korea is using its clandestine nuclear program to make political gain from the U.S., and obtain financial assistance from its neighbors, primarily South Korea. The signed Agreed Framework between the U.S. and DPRK should stop the reprocessing activities at Yongbyon. However, the completion of the 2 LWRs is at least a decade away, and there are problems that could potentially fail the Framework, such as disputes on fuel oil shipment and distribution irregularities, DPRK's internal political turmoil, South Korea's domestic and financial uncertainties, etc.

Remark:	Under the nuclear framework agreement between the U.S. and North Korea, North Korea's nuclear program would fall under even-more severe IAEA scrutiny. How well this arrangement (i.e., international safeguard and security administrated by IAEA) will work is still unknown. An alternative safeguard and security arrangement involving its regional neighbors (i.e., the regional compact framework) would be warranted.
RUSSIAN FAR EAST	
Spent fuel quantity: Accumulated in 1995	Russia's commercial nuclear program in its Far East region is small (120 MWe). However, Russia's Pacific Fleet of nuclear submarines are operated and maintained in the region. The nuclear submarines are required to be defueled periodically, the spent fuel discharged would be transferred into service ships, and brought to shore for interim storage.
Spent fuel storage:	With the end of the Cold War, and the break-up of the Soviet Union, spent submarine fuel discharged from the Pacific Fleet are currently accumulated in the Far East region. The Pacific Fleet would face similar difficulties as the Northern and Arctic Fleet, i.e.: <ul style="list-style-type: none"> <li>- on-shore storage capacity is already filled to the limit,</li> <li>- financially not possible to build additional storage facilities,</li> <li>- railroad system is old and in frequent break-down, shipping the spent fuel to Mayak is limited,</li> <li>- reprocessing capacity at Mayak is too limited to accommodate spent fuel from the far east,</li> <li>- the spent fuels are either stored in storage compartments on-board the service ships, or left in the submarine cores.</li> <li>- these vessels (service ships and submarine) are old, and it is doubtful that they are structurally capable to maintain the spent fuel for indefinite storage.</li> </ul>
Back end policy:	Russia needs financial assistance from the international community to solve its nuclear navy legacy. Several of its actions, such as directly discharging low-level liquid wastes in the Sea of Japan (East Sea), and the direct dumping of entire nuclear submarine cores in the Kara Sea, had received strong international opposition.
Remark:	Under the proposed regional compact framework in East Asia, Russia could offer the services of storing/disposing other's spent fuel and nuclear wastes for a fee. Russia is a declared nuclear weapons state. Its acceptance of others' spent fuel or HLW would have less concern for internal diversion of these materials. In addition, Russia may have to consider a repository in the far east to dispose of spent submarine fuel from its Pacific Fleet.

## Endnotes

1. These ideas are based on two presentations I gave: "A Regional Compact for the Peaceful Use of Nuclear Energy," 19th Planetary Emergency Conference, Erice, Italy, Aug. 1994; and "An East Asian Regional Compact for the Peaceful Use of Nuclear Energy," Energy Workshop of the Northeast Asia Cooperation Dialogue V, Institute of Foreign Affairs and National Security (IFANS), Seoul, Korea, Sept. 11-12, 1996.

2. For a description of the nuclear fuel cycle, see Appendix A, Energy Information Administration, "Nuclear Power Technology and the Nuclear Fuel Cycle," *Nuclear Power Generation and Fuel Cycle Report 1997*, pp. 43-46.
3. Edward Fei, "Nuclear Energy and Nuclear Fuel Cycle Issues in East Asia," paper presented at the Northeast Asia Cooperation Dialogue IV, Beijing, China, Jan. 1996.
4. Brad Roberts and Zachary Davis, "Nuclear Cooperation in the Asia-Pacific: A Survey of Proposals," paper presented at the CSCAP meeting in Singapore, Oct. 29-31, 1996.
5. Robert Manning, "PACATOM: Nuclear Cooperation in Asia," *Washington Quarterly*, 1997, Vol. 20, No. 2, pp. 217-232.
6. Hiroyoshi Kurihara, "Regional Approaches to Increase Nuclear Transparency," undated manuscript.
7. Ryukichi Imai, "Nuclear Arms Control and Non-Proliferation, Looking into the Future," International Institute for Policy Studies (IIPS) Policy Paper 146E, Dec. 1995.
8. William Dircks, "ASIATOM: How Soon, What Role, and Who Should be the Participants?," paper prepared for the Japan-U.S. Study Group on Arms Control and Non-Proliferation After the Cold War, Carnegie Endowment for International Peace and International House of Japan, Tokyo, Japan, Sept. 28-30, 1995.
9. "China Orders Canadian Reactors," *New York Times*, Jul. 15, 1996.
10. Zhaobo Chen, "Development of China's Nuclear Power," paper presented at the Seventh International Conference for Nuclear Cooperation in Asia, Tokyo, Japan, Mar. 5, 1996.
11. Yasutaka Moriguchi, "Government Policy on Recycling of Nuclear Fuel and Peaceful Use of Plutonium," *Japan 21st*, Feb. 1995.
12. Satoshi Isaka, "Reactor Accident Threatens to Stall Fast-Breeder Project," *Nikkei Weekly*, Dec. 18, 1995.
13. *Nuclear Engineering International*, Mar. 1996 and Jan. 1997.
14. *Nuclear Engineering International*, Jun. 1996.
15. Joint U.S.-DPRK press statement, Kuala Lumpur, Malaysia, Jun. 13, 1995.
16. "Facts and Problems Related to Radioactive Waste Disposal in Seas Adjacent to the Territory of the Russian Federation," Office of the President of the Russian Federation, Moscow, 1993; and "Nuclear Wastes in the Arctic: An Analysis of Arctic and Other Regional Impacts From Soviet Nuclear Contamination," Office of Technology Assessment, Congress of the United States, Sept. 1995.
17. "PRC: Nuclear Pact with U.S. Signed in July [1985]," *Nuclear News*, Sept. 1985, pp. 56-59.
18. "Mr. Clinton's New Agenda in Asia," *The New York Times*, Apr. 17, 1996; and "When North Korea Goes Critical," *The Economist*, May 25, 1996.
19. Wolf Hafele, "Do Nothing Scenario for Eastern and Central Europe--Opportunities of an IMRSS," Research Center Rossendorf, Dresden, Germany, Aug. 14, 1995.

20. This is excerpted from a class by G. Bunn of the Center for International Security and Arms Control at Stanford University.
21. Ryukichi Imai and Henry S. Rowen, "Nuclear Energy and Nuclear Proliferation - Japanese and American Views," Westview Press, 1980; and "The Future of Nuclear Weapons," Report of the U.S.-Japan Study Group on Arms Control and Non-Proliferation After the Cold War, Carnegie Endowment for International Peace, 1995.
22. J. D. Sullivan, D. S. Cox, "AECL's Progress in developing the DUPIC Fuel Fabrication Process," AECL, Chalk River Laboratory, Chalk River, Ontario, Canada.
23. The Daily Yomiuri, August 24, 1996.
24. Bao-zhu Tian, "The design of spent fuel storage facility," Beijing Institute of Nuclear Engineering, paper presented at the Sino-American Symposium on Nuclear Safety, Beijing, August 19-23, 1996.
25. Yun-Qing Jiang and Xiao-Qing Li, "Spent fuel management in China," Everclean Environmental Engineering Corp., China National Nuclear Corporation, paper presented at the Sino-American Symposium on Nuclear Safety, Beijing, August 19-23, 1996.
26. Wang Jiaming, "Brief introduction to the transport of radioactive material in China," China Institute for Radiation Protection, paper presented at the Sino-American Symposium on Nuclear Safety, Beijing, August 19-23, 1996; Zuo Min and Li Wenchao, "The spent fuel transporting cask RY-I (RY-LA) and BQH-20," Beijing Institute of Nuclear Engineering, paper presented at the Sino-American Symposium on Nuclear Safety, Beijing, August 19-23, 1996.