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### **U.S.-ROK Nuclear Energy Cooperation: A U.S. View**

The announcement in late December 2009 that a consortium led by the Korea Electric Power Company had won the bid for four new reactors worth over \$20 billion in the United Arab Emirates surprised some nuclear suppliers, including the French giant AREVA. AREVA reportedly is rethinking its marketing strategy, dusting off older, smaller, and cheaper reactors that may be more attractive to states seeking to get into the nuclear energy business for the first time. What may have surprised other nuclear suppliers more was the January 2010 statement by Minister of Knowledge Economy Choi Kyunghwan that the ROK was planning to export 80 reactors overseas, with the intention of securing 20% of the international market by 2030. Reportedly, South Korean industry will seek to become self-sufficient by 2012, with no residual intellectual property constraints.<sup>1</sup>

The KEPCO contract is a major milestone for the Korean nuclear industry and illustrates just how far and how quickly Korean nuclear energy has come in the last twenty years. At home, South Korea operates twenty nuclear power reactors that supply 40% of its electricity needs. Six additional reactors are under construction and four more are on order. Plans envision nuclear power supplying 60% of Korea's electricity needs by 2030 and a functioning, next-generation fast reactor and a pyroprocessing fuel cycle by 2028.

South Korea's nuclear expansion plans face technical and political hurdles both at home and abroad, particularly with regard to spent fuel management. Most spent fuel from the ROK's power reactors is stored at the reactors, but these sites reportedly will reach capacity by 2016. An away-from-reactor storage site has been planned but it is unlikely to be ready by 2016. With its planned nuclear capacity, South Korea could produce almost 100,000 tons of spent fuel by 2100.<sup>2</sup> Dry-cask storage, interim storage, and locating a geological waste repository all face significant domestic political hurdles.

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<sup>1</sup> World Nuclear Association, "Nuclear Power in Korea," 13 January 2010.

<sup>2</sup> Fred McGoldrick, *New U.S.-ROK Peaceful Nuclear Cooperation Agreement: A Precedent for a New Global Nuclear Architecture*, Center for US-Korea Policy, Asia Foundation, November 2009, page 3.

Both short- and long-term solutions are complicated by the ROK's continued dependence on its nuclear partners. Almost 60 percent of the spent fuel stored is U.S.-origin and hence cannot be treated without U.S. approval. Therefore, Korea is likely to consider the disposition of that fuel a key issue in the renegotiation of the US-Korean peaceful nuclear cooperation agreement, which is set to expire in 2014. Options that may appear attractive to the Republic of Korea include advance, long-term consent to reprocess that spent fuel, possibly using advanced processes.

According to press reports and informal discussions with Korean diplomats, the ROK may also seek to acquire uranium enrichment capabilities in order to strengthen its hand as a nuclear supplier. The acquisition of enrichment and reprocessing capabilities at this time in particular is controversial, since there is great impetus to rein in sensitive fuel cycle capabilities as the world contemplates new nuclear powers like the DPRK, the potential for Iran to develop nuclear weapons, and the ever-present threat of nuclear terrorism. In the long term, South Korea could choose to develop a full nuclear fuel cycle on its own, but the financial and political costs would be very high. The United States, which has been at the forefront of efforts to manage the fuel cycle, is sensitive to the potential for the ROK's decisions in this area to set precedents for other states.

### **Past Peaceful Nuclear Energy Cooperation between US and ROK**

The United States and the Republic of Korea have cooperated in the field of peaceful nuclear energy for more than fifty years. During that time, the scope of collaboration has expanded to meet the ROK's growing capabilities and U.S. interest in tapping into advanced nuclear technology. The first two decades of cooperation focused on nuclear research reactors (General Atomics' Triga Mark II reactors) and then expanded to power reactors with the Westinghouse-designed Kori-1 pressurized water reactor, which began operating in 1978.

In the 1990s, the ROK began modifying Westinghouse, Framatome (now Areva) and Combustion Engineering technology and introduced its own Korean Standard Nuclear Power Plant in 1996 (subsequently rebranded as the OPR-1000). The ROK is now emerging as an international supplier of nuclear power reactors, as witnessed by the recent decision of the United Arab Emirates to purchase third-generation APR-1400 reactors. The deal reportedly includes four APR-1400s worth over \$20 billion. According to press reports, Korean industry is also looking to export power reactors to Turkey, Kazakhstan, Thailand, South Africa and Vietnam, as well as a small research reactor to Jordan.

In addition to power reactors, US-ROK peaceful nuclear energy cooperation spans a range of research applications, as well as fuel cycle technologies. For many years, the United States cooperated with the ROK on DUPIC technology (direct-use of spent PWR fuel in CANDU reactors) and since 2005, ROK and U.S. scientists have been collaborating on pyroprocessing, an electrometallurgical process that separates uranium from plutonium and fission products, leaving the "hot" plutonium to be recycled as fuel for fast reactors. Pyroprocessing was briefly considered within the Global Nuclear

Energy Partnership as a candidate for recycling techniques that offer improved proliferation resistance over the traditional PUREX method, which separates out plutonium. The U.S. Department of Energy's 2008 Draft Nonproliferation Impact Assessment (NPIA) concluded, however, that the reprocessing alternatives under discussion, including pyroprocessing, offered only small improvements over PUREX in reducing proliferation risks, primarily affecting the risk that non-state actors would be able to gain access to the plutonium.<sup>3</sup>

While the Bush administration championed nuclear power at home and abroad, including spent fuel reprocessing, the approach of the Obama administration is not yet so straightforward. Several Bush initiatives, such as nuclear cooperation agreements with India and the UAE, are being carried forward. Although aggressive efforts to commercialize recycling under GNEP in the United States have disappeared, the international component of GNEP continues. Nonetheless, there is no clearly defined Obama vision of what a sustainable nuclear future might look like and this makes it difficult to predict the extent of support for specific nuclear fuel cycle options, like fast reactors and fuel recycling.

### **The Framework Agreement**

The ROK's peaceful nuclear cooperation agreement with the United States was last amended in 1974 and must be renegotiated by 2014. In addition to passage of the 1978 Nuclear Nonproliferation Act, which requires the agreement to contain certain nonproliferation measures, U.S. policy will also shape the scope of the agreement. Under the terms of the old agreement, U.S. consent rights applied to nuclear material supplied by the United States. Article VIII of the existing agreement, as amended in 1974, provided that:

C. When any special nuclear material received from the United States of America pursuant to this Agreement or the superseded Agreement requires reprocessing, or any irradiated fuel elements containing fuel material received from the United States of America pursuant to this Agreement or the superseded Agreement are to be removed from a reactor and are to be altered in form or content, such reprocessing or alteration shall be performed in facilities acceptable to both Parties upon a joint determination of the Parties that the provisions of Article XI may be effectively applied.

The United States has not consented to any alteration in form or content of U.S.-origin spent nuclear fuel in Korea. Since the passage of the 1978 NNPA, which sought to tighten control on exported U.S. nuclear material, including also nuclear material that has been used in a U.S.-supplied reactor, several administrations have implemented what has become known as long-term or programmatic consent for reprocessing. Such arrangements have been granted consistently only to countries that already have

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<sup>3</sup> Office of Nonproliferation and International Security, Department of Energy, *Draft Nonproliferation Impact Assessment Statement for the Global Nuclear Energy Partnership Programmatic Alternatives*, December 2008, p. 69.

advanced nuclear programs, including reprocessing and enrichment plants.<sup>4</sup> Additional criteria have been applied, including that countries must pose no proliferation risk, be located in regions of only limited proliferation concern, and have excellent nonproliferation credentials. To date, the United States has approved the reprocessing of U.S.-origin spent nuclear fuel only in EURATOM and Japan—and has agreed to consent to such reprocessing in a future Indian reprocessing facility.

In a recent report for the Asia Foundation entitled, *New U.S.-ROK Peaceful Nuclear Cooperation Agreement: A Precedent for a New Global Nuclear Architecture*, author Fred McGoldrick notes that Under Secretary of State Ellen Tauscher's written answers to the Senate Foreign Relations Committee on allowing reprocessing in states such as Taiwan or South Korea were equivocal. She wrote that "The Administration does not believe that such programmatic consent to reprocessing is necessarily appropriate in other cases, including Taiwan and the Republic of Korea." In response to the specific question of whether Tauscher believed "that an agreement that allowed any form of reprocessing to take place in South Korea would violate the 1992 Joint Declaration, in particular its clear statement that 'The South and the North shall not possess nuclear reprocessing and uranium enrichment facilities,'" Tauscher responded that "the existence of a reprocessing plant in the Republic of Korea would be inconsistent with the commitments made in the 1992 Joint Declaration."

In addition to consent rights, other key issues to discuss under the new framework agreement will likely include the extent and nature of U.S.-South Korean cooperation in fuel recycling techniques such as pyroprocessing, and cooperation in development of thermal fast reactors.

ROK scientists have been conducting pyroprocessing-related research since 1997, but collaboration with U.S. scientists began about five years ago under the DoE's International Nuclear Energy Research Initiative with U.S. national laboratory scientists at Argonne and Idaho. Research on safeguards for pyroprocessing commenced in 2002, and Korean scientists have collaborated both with the IAEA and Los Alamos National Laboratory scientists on safeguards since then.

In December 2008, the ROK's Atomic Energy Commission released a long-term research and development plan that included pyroprocessing and fast reactors.<sup>5</sup> A laboratory-scale Advanced Spent Fuel Conditioning Facility has been operational since 2008, although no irradiated fuel has been introduced. The ROK plans to establish an engineering-scale mock-up by 2012 and to demonstrate an engineering-scale process by 2016. A commercial-scale demonstration plant is planned for 2025. To this point, the United States has only allowed processing with irradiated fuel to occur in the United States. For the Korean program to move forward, it must gain experience working with irradiated fuel in its own facilities.

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<sup>4</sup> McGoldrick, *op cit*, page 5.

<sup>5</sup> Seong Won Park, "Why South Korea Needs Pyroprocessing," *Bulletin of Atomic Scientists*, October 26, 2009

South Korean scientists are also involved in development of a sodium-cooled fast reactor KALIMER (Korean Advanced Liquid Metal Reactor) and a very high temperature gas-cooled reactor as part of their efforts to develop the next generation of reactors under the Gen IV International Forum.

Enrichment and reprocessing cooperation could be raised by the South Koreans as a topic for discussion under 123 agreement negotiations. The 2007 US-India peaceful nuclear cooperation agreement opened a Pandora's box on enrichment and reprocessing cooperation. Specifically, Article 5.2 of the agreement stated:

Sensitive nuclear technology, heavy water production technology, sensitive nuclear facilities and major critical components of such facilities may be transferred under this Agreement pursuant to an amendment to this Agreement.

Besides the India agreement, only one other U.S. nuclear cooperation agreement allows for such transfers, and in that case, the agreement was amended to accommodate enrichment technology transfers from Australia to the United States. Such cooperation with India is not assured, since an amended agreement would require approval by the U.S. Congress. Nonetheless, South Korea might also desire to keep the door open for future possibilities. The Obama administration is unlikely to favorably consider enrichment and reprocessing cooperation with South Korea.

If, in fact, the agreement prohibits the transfer of such technologies, it would be important for South Korea to establish that pyroprocessing is not sensitive nuclear technology, which is typically defined in U.S. agreements as “any information that is not in the public domain and that is important to the design, construction, fabrication, operation, or maintenance of any sensitive nuclear facility, or other such information that may be so designated by agreement of the Parties.”<sup>6</sup>

### **ROK and Nuclear Sovereignty?**

Some observers have characterized South Korea as a state pursuing nuclear sovereignty. This could be interpreted as a drive for more independence in developing fuel cycle capabilities, notably uranium enrichment and spent fuel reprocessing or recycling. Factors that likely influence the ROK's perspective include competition with Japan, which has full nuclear fuel cycle capabilities, North Korea's abrogation of its commitment under the 1992 Joint Declaration on the Denuclearization of the Korean Peninsula to forswear enrichment and reprocessing, and the example of India, whose nuclear cooperation agreement with the United States allows for, in principle, advance long-term consent to reprocess U.S.-origin spent fuel. South Korea, like several other states, is also eyeing the international nuclear supply market.

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<sup>6</sup> Here, the definition of sensitive nuclear facility is key. In US 123 agreements, this is typically defined as “any facility designed or used primarily for uranium enrichment, reprocessing of nuclear fuel, or fabrication of nuclear fuel containing plutonium.”

In particular, ROK officials have argued that the size of South Korea's nuclear energy program, the need for energy security, the build-up of spent fuel and difficulties in choosing a site for a geological waste repository, as well as South Korea's plans to build thermal fast reactors, make recycling fuel attractive, if not inevitable. As noted above, U.S. consent would be required to alter in form or content much of the existing spent fuel in South Korea. In the past, concern about not promoting the use of plutonium in the civil fuel cycle weighed heavily against U.S. consent for reprocessing.<sup>7</sup>

There is another possibility for South Korea, which is to send its spent fuel overseas for reprocessing. There are several disadvantages to this, particularly if South Korea hopes to use plutonium in fast reactors, which include cost, security, and logistics. However, if the recent U.S.-UAE nuclear cooperation agreement is any guide, U.S. officials may be more amenable to providing what appears to amount to advance consent for the UAE to send U.S.-origin spent fuel abroad for reprocessing. In that agreement, the issue is treated almost as a transfer issue, wherein the UAE must simply inform the United States of transfers. However, there are certain restrictions that South Korea would likely not accept. The first is that the resultant plutonium may not be returned to the UAE. The second is that France and the UK are specifically identified as countries where the UAE may send spent fuel for reprocessing. The third is that the UAE agreement contains an explicit declaration that the UAE will not pursue enrichment and reprocessing. Although this approach may be unobjectionable to a state just embarking on a nuclear energy program, it is unlikely to appeal to a state with an advanced nuclear program such as the ROK.

Current U.S. policies on the further spread of enrichment and reprocessing technology seem to reflect an *ad hoc* approach that could complicate negotiations with the ROK. On the one hand, the United States is encouraging states with which it is negotiating new cooperation agreements to forswear enrichment and reprocessing. Yet, while the UAE agreement included this restriction, the United States apparently has not been as successful with other states, for example, Jordan, in promoting this approach.

Finally, the importance of the political and security conditions prevailing on the Korean peninsula in affecting the upcoming 123 agreement negotiations should not be underestimated. North Korea has an active nuclear weapons program and has violated many bilateral (both DPRK-ROK and DPRK-US) agreements, has tested nuclear weapons, and dropped out of the Nuclear Nonproliferation Treaty. Negotiations with North Korea concerning the transparency and dismantlement of its nuclear program are likely to have an important impact on the U.S. approach to dealing with the management of South Korea's spent fuel that is subject to the U.S.-ROK peaceful nuclear cooperation agreement. This issue is likely to be important to both the Executive Branch and Congress. Regardless of whether one's views on negotiating with North Korea are hawkish or dovish, it is hard to imagine a member of Congress who would support facilitating spent fuel recycling by South Korea if it is seen to make negotiations with North Korea more difficult.

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<sup>7</sup> Mark Hibbs, "Korea's Long-Term Ambition is Fresh Nuclear Pact with U.S.," *Nuclear Fuel*, December 2, 1996, p. 4.

## Nonproliferation Issues

With states that the United States is considering nuclear cooperation for the first time, U.S. officials clearly consider a state's nonproliferation performance and credibility in assessing the scope and level of cooperation. In the case of South Korea, it's a bit more complicated. Despite many decades of excellent cooperation, U.S. officials will still have to consider the history of South Korea's nuclear weapons program,<sup>8</sup> continued South Korean interest in reprocessing,<sup>9</sup> and undeclared activities reported in 2004 in the process of making Additional Protocol declarations.<sup>10</sup> A U.S. assessment of the impact of these activities, as well as the corrective steps that the ROK has taken and the reports of the IAEA on South Korean compliance with its safeguards obligations, will be provided to the U.S. Congress in a Nonproliferation Assessment Statement. The U.S. Congress is likely to be interested in how pyroprocessing differs from reprocessing, and whether such activities might conflict with the 1992 Joint Declaration on the Denuclearization of the Korean Peninsula that prohibits enrichment and reprocessing facilities. Above all, developments regarding North Korea's nuclear program will figure prominently in any internal executive branch deliberations.

A country's nonproliferation record factors into any assessment, including the extent to which a state has embraced nonproliferation norms and practices. South Korea is a party to the NPT, a member of the MTCR, Australia Group, Wassenaar Arrangement, and NSG and signed its Additional Protocol in 2004. It submitted its first report to the Security Council under UNSCR 1540 also in 2004. Following the revelations in 2004 of unreported nuclear activities, the government of the Republic of Korea announced its "Four Principles for the Peaceful Use of Nuclear Energy" in September 2004. These included that the ROK:

- has no intention of developing or possessing nuclear weapons;
- firmly maintains the principle of nuclear transparency and will strengthen cooperation with the international community to this end;
- will abide by international agreements on nuclear nonproliferation;
- and will expand the peaceful use of nuclear energy on the basis of international confidence.

Some critics have argued that the fourth assurance – expansion of the peaceful use of nuclear energy on the basis of international confidence – can be interpreted as a reassertion of South Korea's right to pursue plutonium recycling in contrast to an explicit

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<sup>8</sup> Mark Hibbs, "ROK military said to have begun nuclear weapons plan in 1980s," *Nucleonics Week*, November 18, 2004.

<sup>9</sup> See, for example, Jungmin Kang and Hal Feiveson, "South Korea's Shifting and Controversial Interest in Spent Fuel Reprocessing," *The Nonproliferation Review*, Spring 2001, pp. 70-78.

<sup>10</sup> Daniel Horner and Mark Hibbs, "South Korea calls fuel-cycle testing a 'technical violation,'" *Nucleonics Week*, October 14, 2004.

abandonment of its policy to close the fuel cycle.<sup>11</sup> This issue may influence perceptions of South Korea's nonproliferation credibility more than others.

### **ROK – Unique or a Trend-Setter?**

U.S. policy is most easily defended when it applies universal principles in a consistent fashion, but most easily implemented when tailored to specific situations. In the area of nuclear energy cooperation, the United States has had difficult periods of consistency and many exceptions in between. As the Obama administration seeks to shape the nuclear future it desires, it will certainly take into account the following factors:

- the need to enhance nuclear materials security and minimize growing stockpiles of separated, civilian plutonium
- the need to create fuel cycle approaches that minimize incentives for states to acquire sensitive nuclear technologies like uranium enrichment and spent fuel reprocessing
- the need to avoid solutions that segregate capabilities between “haves” and “have-nots”

Such an approach would steer U.S. officials away from plans for overseas reprocessing of Korean spent nuclear fuel and toward more multilateral approaches. A joint or multilateral pyroprocessing facility, one of the options described by Fred McGoldrick in his Asia Foundation report, could gain favor as an approach that would not set a precedent that could have negative implications for other regions. However, this could conflict with existing U.S. policy not to introduce sensitive technologies in regions of proliferation concern.

A few specific developments in the next few years could influence the U.S. approach toward scoping US-ROK nuclear cooperation:

- the extent to which a nuclear “renaissance” truly takes off in the U.S. and elsewhere
- agreement within the nonproliferation community on further restrictions regarding the spread of enrichment and reprocessing technology
- disarmament discussions and/or progress with the DPRK

In addition, other developments on fuel cycle issues could shape the willingness of the United States to explore South Korea's acquiring additional fuel cycle capabilities. For example, a solution to the Iranian crisis that incorporates multinational facilities could make it very difficult to support what appears to be acquisition of sensitive nuclear technologies on a national level.

Significant new nuclear reactor construction in the United States was dealt a blow by the recent decision by Florida Power and Light to abandon the Turkey Point reactors (because the Florida Public Utility Commission rejected FPL's request to increase rates

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<sup>11</sup> Jungmin Kang, Peter Hayes, Li Bin, Tatsujiro Suzuki and Richard Tanter, “South Korea's Nuclear Surprise,” *Bulletin of Atomic Scientists*, January/February 2005, Vol. 61, No. 1, p. 48.

to help pay for the reactors). With the suspension of several license applications under review at the Nuclear Regulatory Commission and little progress on a price for carbon, the economic prospects for new reactors in the United States continue to be precarious. The Obama administration's plan to increase loan guarantees from \$18 billion to \$54 billion, however, should provide a little relief. Regardless of what happens in the United States, the robustness of the global nuclear renaissance will affect how urgently U.S. officials perceive the challenge of managing the nuclear fuel cycle. In particular, South Korea's push to export scores of reactors will likely raise interest in discussions about nonproliferation commitments that should be embedded in nuclear cooperation agreements that South Korea concludes with other nations.

Another development that might affect South Korean plans would be an agreement among Nuclear Suppliers Group members to implement new and more detailed criteria for restricting enrichment and reprocessing transfers. Despite discussions since 1994, NSG members have not yet agreed upon new, detailed criteria. In 2008, the United States introduced draft language that would have bound parties to previous agreements not to acquire sensitive nuclear technology. In that formulation, South Korea would not have been free to acquire enrichment or reprocessing technology by virtue of the 1992 agreement with North Korea. However, that language no longer appears in the draft guidelines, according to diplomatic sources. It is not clear when the NSG will make sufficient progress to reach agreement. Nonetheless, it is not out of the question that even if South Korea met all the NSG criteria for transfers of enrichment and reprocessing, that other NSG members might still be wary about the effect of any reprocessing transfer to the ROK on regional stability and about its compatibility with the 1992 Joint ROK-DPRK Declaration on the Denuclearization of the Korean Peninsula.

For the United States in particular, the compatibility of ROK pyroprocessing with the 1992 Joint Declaration may be especially difficult to discern. As noted earlier, Under Secretary of State Ellen Tauscher stated for the record that "the existence of a reprocessing plant in the Republic of Korea would be inconsistent with the commitments made in the 1992 Joint Declaration." If progress with the DPRK recedes even further from view, the joint declaration may not be as important as it has been. However, that vantage point is impossible to predict. As far as setting precedents, a South Korea with an advanced nuclear power program that does not require spent fuel reprocessing serves several current U.S. nuclear energy, nuclear nonproliferation, and regional policy objectives simultaneously.

### **Concluding Thoughts**

South Korea poses unique challenges for U.S. nuclear nonproliferation policy as the two countries prepare to renew their peaceful nuclear energy cooperation agreement. Sharing a border with the DPRK, the only state ever to have withdrawn from the Nuclear Nonproliferation Treaty, South Korea has a thriving nuclear energy program and advanced nuclear energy R&D. Motivated by growing interest overseas in nuclear energy, the ROK may seek to acquire uranium enrichment capabilities, and will seek to develop spent fuel recycling capabilities to handle its accumulating spent fuel. U.S.

decisions on the scope and content of the new peaceful nuclear cooperation agreement could help or hinder achieving these objectives.

Efforts to limit the spread of sensitive fuel cycle capabilities on a multilateral level have flagged as the perception of nuclear energy as an attractive solution to energy security and global climate change has grown. The United States has been attempting to limit such capabilities on a bilateral basis through its nuclear cooperation agreements with the hope that precedents will be set and enthusiasm for more proliferation-resistant agreements will grow. Here, the precedent of the case of the UAE may be instructive: although the US-UAE agreement contains certain restrictions and rights, there is no guarantee that agreements the UAE concludes with other states contain the same restrictions. In fact, the first reactors the UAE will build will be South Korean and the UAE may not, in fact, purchase U.S. reactors. This means that as South Korean industry prepares to take a significant leading role in supplying reactors and other nuclear technology, its own nonproliferation requirements for nuclear supply may also play a critical role in stemming proliferation. As such, U.S. interest in supporting a more reciprocal relationship may continue to grow.