



U.S. and South Korean Cooperation in the World Nuclear Energy Market: Major Policy Considerations

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January 21, 2010

Congressional Research Service

7-5700

www.crs.gov

R41032

Summary

A South Korean consortium recently signed a contract to provide four commercial nuclear reactors to the United Arab Emirates (UAE), signaling a new role for South Korea in the world nuclear energy market. The \$20 billion deal indicates that South Korea has completed the transition from passive purchaser of turn-key nuclear plants in the 1970s to major nuclear technology supplier, capable of competing with the largest and most experienced nuclear technology companies in the world. The South Korean government reportedly has established a goal for South Korea to capture 20% of the world nuclear power plant market during the next 20 years, and the importance placed by Seoul on the UAE contract was underscored by South Korean President Lee Myung-bak's presence at the signing ceremony in the UAE.

In the 1970s, South Korea launched its nuclear power program through the government-owned Korea Electric Company (now Korea Electric Power Corporation, KEPCO), which purchased the country's first nuclear power units from Westinghouse. In the early years of the Korean nuclear program, Westinghouse and other foreign suppliers delivered completed plants with minimal Korean industry input. After the first three units, Korean firms took over the construction work on subsequent plants, although the reactor systems, turbine-generators, and architect/engineering services continued to be provided primarily by non-Korean companies. In 1987, KEPCO embarked on an effort to establish a standard Korean design, selecting the System 80 design from the U.S. firm Combustion Engineering as the basis. Combustion Engineering won the competition for the Korean standard design contract by agreeing to full technology transfer, according to KEPCO. The technology transfer program resulted in the development of the AP-1400 power plant, which is the design purchased by the UAE.

In the UAE deal, the South Korean consortium is headed by KEPCO and includes other major Korean industrial companies that are involved in Korea's rapidly growing domestic nuclear power plant construction program. The consortium also includes Pittsburgh-based Westinghouse Electric Company, which currently owns the U.S. design on which the Korean design is based, and the Japanese industrial conglomerate Toshiba, which now owns most of Westinghouse.

Because the AP-1400 is based on a U.S. design, U.S. export controls will continue to apply. Westinghouse plans to seek the necessary authorization from the U.S. Department of Energy (DOE) to transfer the technology to the UAE. The UAE recently reached a nuclear cooperation agreement with the United States in which the country agreed not to develop fuel cycle facilities to support its planned nuclear power program, which could ease weapons proliferation concerns. The UAE program may establish a precedent for U.S. policy on future Korean exports to non-nuclear power nations, which is likely to be of continuing congressional interest.

The Korea-UAE nuclear plant sale also has been cited by the Korean news media as an important consideration in upcoming negotiations on the renewal of the U.S.-Korea nuclear cooperation agreement, a prerequisite under Section 123 of the Atomic Energy Act for nuclear trade. The current agreement expires in 2014, and the first discussions on renewal are likely within the next year. Congress will have an opportunity to review any new agreement before it takes effect.

Contents

Introduction: South Korea’s New World Role	1
Domestic South Korean Nuclear Energy Program	2
South Korean Nuclear Plant Export Program.....	5
UAE Reactor Contract	5
Korean and U.S. Partnership	6
Outlook for Korean Exports	7
U.S. Policy Considerations	9

Figures

Figure 1. South Korean Nuclear Power Units	3
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Contacts

Author Contact Information	11
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Introduction: South Korea's New World Role

South Korean consortium recently signed a contract to provide four commercial nuclear reactors to the United Arab Emirates (UAE), signaling a new role for South Korea in the world nuclear energy market. The \$20 billion deal indicates that South Korea (the Republic of Korea, ROK) has completed the transition from passive purchaser of turn-key nuclear plants in the 1970s to major nuclear technology supplier, now capable of competing with the largest and most experienced nuclear technology companies in the world.

Because the plants being exported by South Korea are based on a U.S. design, U.S. export controls will continue to apply. Westinghouse plans to seek the necessary authorization from the U.S. Department of Energy (DOE) to transfer the technology to the UAE. The UAE recently reached a nuclear cooperation agreement with the United States in which the country agreed not to develop fuel cycle facilities to support its planned nuclear power program, which could ease weapons proliferation concerns. The UAE program may establish a precedent for U.S. policy on future Korean exports to non-nuclear power nations, which is likely to be of continuing congressional interest.

The Korea-UAE nuclear plant sale has been cited by the Korean news media as an important consideration in upcoming negotiations on the renewal of the U.S.-Korea nuclear cooperation agreement, a prerequisite under Section 123 of the Atomic Energy Act for nuclear trade. Korean newspaper editorials have suggested that Korea's first foreign sale of nuclear technology could pave the way for U.S. agreement for Korean reprocessing of spent nuclear fuel, which is currently not permitted. The Korean Minister of the Knowledge Economy called for Korea to achieve "peaceful nuclear sovereignty" under future U.S. agreements.¹ The current agreement expires in 2014, and the first discussions on renewal are likely within the next year. Congress will have an opportunity to review any new agreement before it takes effect.

South Korea's nuclear technology progression has been similar to the earlier nuclear paths of France and Japan, and which appears likely to be followed in the future by China. France, Japan, and now South Korea developed their nuclear power industries with technology and designs licensed from U.S. companies to supply domestic energy needs. In each case, the licensees assumed progressively greater responsibility for construction of the U.S.-designed units and eventually the engineering and design as well. The foreign firms now compete for nuclear plant contracts throughout the world, including the United States, either in consortia with their former U.S. licensors or independently.

In the UAE deal, the South Korean consortium is headed by government-owned Korea Electric Power Corporation (KEPCO) and includes other major Korean industrial companies that are involved in Korea's rapidly growing domestic nuclear power plant construction program. The consortium also includes Pittsburgh-based Westinghouse Electric Company, which currently owns the U.S. design on which the Korean design is based, and the Japanese industrial conglomerate Toshiba, which now owns most of Westinghouse.

¹ "Seoul Wants 'Sovereignty' in Peaceful Nuclear Development," *Chosun Ilbo*, December 31, 2009.

Although Korean companies now take the lead on design and construction of Korea's nuclear power plants, Westinghouse still provides support under the design license. Such support typically includes components, instrumentation and control equipment, and technical and engineering services. The Korean plant to be built in the UAE, the APR-1400 model, is a modified version of the System 80+ design developed by the U.S. firm Combustion Engineering (C-E), which was later acquired by Westinghouse. Westinghouse has estimated that its work under the UAE contract could total \$1 billion.²

Domestic South Korean Nuclear Energy Program

When the construction of South Korea's first commercial nuclear power plant began in 1972, the South Korean economy was about 7.5% the size of Japan's, and the country's per-capita income was slightly lower than that of North Korea.³ With such a relatively small industrial base, South Korea's plans to finance and operate a fleet of nuclear power plants could have been considered overly ambitious, and its long-term plans to master the new technology might have seemed unrealistic. But the subsequent growth of the South Korean economy—with per-capita income now rivaling other developed nations and GDP nearly 20% of Japan's—turned out to be more than sufficient to sustain the country's planned nuclear power development.

South Korea launched its nuclear power program through the government-owned Korea Electric Company (now Korea Electric Power Corporation, KEPCO), which purchased the country's first nuclear power units from Westinghouse. Those first plants were ordered on a turn-key basis, in which the foreign supplier delivered a completed plant with minimal Korean industry input. As shown in **Figure 1**, the first of these turn-key units, Kori 1, began operating in 1978. Westinghouse supplied the reactor and other components of the nuclear steam supply system (NSSS) and constructed the plant, and other western firms provided the turbine-generator and architect/engineering services. Wolsong 1 and Kori 2, coming on line in 1983, were also turn-key units, with all major components and construction services provided primarily by non-Korean companies.

After those first three units, Korean firms took over the construction work on subsequent plants, beginning with Kori 3, which began commercial operation in 1985. However, the NSSS, turbine-generators, and architect/engineering services continued to be provided primarily by non-Korean companies, including Westinghouse, Atomic Energy of Canada Limited (AECL), and the French firm Framatome, which had previously licensed its design from Westinghouse. That arrangement continued for the next six units, which came on line from 1995-1999.

In 1987, KEPCO embarked on an effort to establish a standard Korean design, selecting the System 80 design from the U.S. firm Combustion Engineering (C-E) as the basis.⁴ The System 80 design had been used for three identical units nearing completion at Palo Verde, Arizona.

² E-mail from Jeanne T. Lopatto, Vice President, Government and International Affairs, Westinghouse Electric Company, January 5, 2010.

³ Angus Maddison, *The World Economy: Historical Statistics*, Organization for Economic Cooperation and Development, 2006, pp. 298-306.

⁴ World Nuclear Association, South Korea Country Report, January 7, 2010, <http://www.world-nuclear.org/info/inf81.html>.

Figure I. South Korean Nuclear Power Units

Major Categories of Work Conducted By Domestic and Foreign Companies

Year of Operation/ Reactor Name	Reactor Supplier	Generator Supplier	Architect Engineer	Construction Contractor
1978 Kori 1	Westinghouse	GE (UK)	Gilbert	Westinghouse
1983 Wolsong 1	AECL	NE (UK)	AECL	AECL
1983 Kori 2	Westinghouse	GE (UK)	Gilbert	Westinghouse
1985 Kori 3	Westinghouse	GE (UK)	Bechtel	Hyundai
1986 Kori 4	Westinghouse	GE (UK)	Bechtel	Hyundai
1986 Yonggwang 1	Westinghouse	Westinghouse	Bechtel	Hyundai
1987 Yonggwang 2	Westinghouse	Westinghouse	Bechtel	Hyundai
1988 Ulchin 1	Framatome	Alstom	Framatome	Dong Ah/Hanjung
1989 Ulchin 2	Framatome	Alstom	Framatome	Dong Ah/Hanjung
1995 Yonggwang 3	Hanjung/C-E	Hanjung/GE	KOPEC/S&L	Hyundai
1996 Yonggwang 4	Hanjung/C-E	Hanjung/GE	KOPEC/S&L	Hyundai
1997 Wolsong 2	AECL/Hanjung	Hanjung/GE	AECL/KOPEC	Hyundai
1998 Wolsong 3	AECL/Hanjung	Hanjung/GE	AECL/KOPEC	Daewoo
1998 Ulchin 3	Hanjung/C-E	Hanjung/GE	KOPEC/S&L	Dong Ah/Hanjung
1999 Wolsong 4	AECL/Hanjung	Hanjung/GE	AECL/KOPEC	Daewoo
1999 Ulchin 4	Hanjung/C-E	Hanjung/GE	KOPEC/S&L	Dong Ah/Hanjung
2002 Yonggwang 5	Doosan	Doosan	KOPEC	Hyundai/Daelim
2002 Yonggwang 6	Doosan	Doosan	KOPEC	Hyundai/Daelim
2004 Ulchin 5	Doosan	Doosan	KOPEC	Dong Ah/Doosan/Samsung
2005 Ulchin 6	Doosan	Doosan	KOPEC	Dong Ah/Doosan/Samsung

Non-Korean
Companies

Non-Korean and
Korean Companies

Korean Companies

AECL: Atomic Energy of Canada Ltd. KOPEC: Korea Power Engineering Company
 C-E: Combustion Engineering NE: Northern Engineering
 GE: General Electric S&L: Sargent & Lundy

Source: Nuclear News, *World List of Nuclear Power Plants*, March 2009.

Combustion Engineering won the competition for the Korean standard design contract by agreeing to full technology transfer, according to KEPCO. The U.S. contractors for the turbine-generators (General Electric) and architect/engineering services (Sargent & Lundy) agreed to transfer key technology as well.

All of the major U.S. companies working on the new C-E plants agreed to serve as subcontractors to Korean firms: Combustion Engineering to Hanjung (now Doosan), General Electric (GE) also to Hanjung, and Sargent & Lundy (S&L) to Korea Power Engineering Company (KOPEC), which is majority owned by KEPCO.⁵ Yonggwang 3 and 4 and Ulchin 3 and 4, which began operating from 1995 to 1999, were constructed under that arrangement. A similar partnership was formed with Atomic Energy of Canada Limited (AECL) to build Wolsong 2-4, completed during 1997 through 1999. Plant construction continued to be carried out by Korean companies. Components and work shared by Korean and foreign firms is shown in **Figure 1**.

Korean reactor designers worked with C-E, which became part of Westinghouse in 2000, to develop a standard Korean design from the System 80 model. This effort resulted in the 1,000 megawatt Optimized Power Reactor (OPR-1000). The four OPR-1000 units that have been completed since 1999, Yonggwang 5-6 and Ulchin 5-6, were built and constructed almost entirely by Korean firms. However, some key components continued to be supplied or heavily supported by non-Korean firms, constituting a small percentage of each nuclear unit's total cost.

Development of a larger and more advanced model of the Korean standard design was based on the C-E System 80+ design that received U.S. standard design certification from the Nuclear Regulatory Commission (NRC) in May 1997. The Korea Atomic Energy Research Institute (KAERI) helped develop the U.S. design,⁶ complementing work on the Korean version of the design that began in 1992. The Korean design was largely completed by 1999 and was designated the APR-1400.⁷

South Korea currently has eight nuclear units under construction, four OPR-1000s and four APR-1400s, to be completed between 2010 and 2016. Four more APR-1400s are to be completed between 2018 and 2021. That construction program would increase the country's nuclear power reactors from 20 to 32, and nuclear power generating capacity from 17,700 megawatts to 32,500 megawatts. South Korea's long-term electricity plan calls for increasing nuclear capacity to 42,700 megawatts by 2030, the equivalent of about seven additional APR-1400s after 2021.⁸ South Korea generated 36% of its electricity from nuclear plants in 2008 and plans to increase that share to 59% by 2030.⁹

Ever since South Korea completed the first nuclear unit in which Korean firms participated in all phases of development—Yonggwang 3 in 1995—the country has opened an average of about one unit every 18 months. Starting after the most recent reactor began commercial operation in 2005, Ulchin 6, South Korea plans to complete an average of about one reactor every 16 months through 2021, and potentially about one reactor per year from 2022 to 2030. With the planned rate of domestic nuclear plant construction remaining fairly stable, it would appear that any significant expansion of South Korea's nuclear engineering and construction industry would depend on exports.

⁵ Gary Baker and Shin Ho-Chul, "Korean Utility and Three U.S. Firms Ink Nuclear Building Deal," *Nucleonics Week*, April 16, 1987, p. 5.

⁶ National Academy of Sciences, *Nuclear Power: Technical and Institutional Options for the Future*, Washington, DC, 1992, p. 100.

⁷ World Nuclear Association, op. cit.

⁸ Korea Atomic Energy Research Institute, *Nuclear Power and R&D Programs in Korea*, Presentation to CRS visitors, Daejeon, South Korea, July 27, 2009, pp. 11-12.

⁹ Jae-min Ahn, "Industry Perspectives on Korean Nuclear Program," Presentation to U.S.-ROK Workshop on Nuclear Energy and Nonproliferation, Washington, DC, January 20, 2010.

South Korean Nuclear Plant Export Program

The South Korean government expects KEPCO's reactor sale to the UAE to constitute the leading edge of a much larger nuclear power marketing effort throughout the world. According to news media reports, the Ministry of Knowledge Economy (MKE), which is responsible for industrial and trade policy, has established a goal for South Korea to capture 20% of the world nuclear power plant market during the next 20 years. Based on an estimated world market of about 400 large commercial reactors through 2030, a 20% penetration would result in South Korean exports of 80 reactors during the next 20 years, with an estimated value of \$400 billion.¹⁰

UAE Reactor Contract

As South Korea's first foreign reactor sale, the UAE contract is likely to establish a template for future exports. The companies involved in the UAE project appear to be the same ones that are currently building Korean domestic nuclear plants and are likely to play similar roles in the export program. The importance placed by the ROK government on the contract was underscored by the presence of South Korean President Lee Myung-bak at the signing ceremony in the UAE December 27, 2009, along with UAE President Sheikh Khalifa bin Zayed al-Nahayan.¹¹

The selection of the KEPCO consortium was made by the Emirates Nuclear Energy Corporation (ENEC), which will oversee the contract's implementation. According to a statement issued by ENEC, the contract includes the following major provisions:¹²

- The KEPCO consortium will design, build, help operate and maintain, and provide initial fuel for four APR-1400 nuclear units at a total cost of about \$20 billion. A "high percentage of the contract" will be under a fixed price.
- Korean investors will have an equity interest in the UAE plants.
- The first unit is to begin commercial operation in 2017, with the other three to be completed by 2020.
- Extensive training, human resources development, and education is to be provided to allow UAE to eventually provide most of the nuclear plant staffing and develop commercial infrastructure and support businesses.
- A potential follow-on contract for long-term operation and maintenance of the units, worth as much as another \$20 billion over 60 years,¹³ is under discussion with KEPCO and other vendors.

The Korean consortium was selected over two other proposals, from Areva and General Electric-Hitachi. According to media reports, the decision was strongly affected by price. One report

¹⁰ World Nuclear News. "South Korea Weeks to Boost Reactor Exports," January 13, 2010, http://www.world-nuclear-news.org/NP-South_Korea_seeks_to_boost_reactor_exports-1301104.html.

¹¹ Amena Bakr, "South Korean Group Wins \$40bn UAE Nuclear Deal," *Arabian Business.com*, December 27, 2009.

¹² Emirates Nuclear Energy Corporation, "UAE Selects Korea Electric Power Corp. Team as Prime Contractor for Peaceful Nuclear Power Program," press release, December 27, 2009, <http://www.enec.gov.ae/news/uae-selects-korea-electric-power-corp-team-as-prime-contractor-f/>.

¹³ Bakr, op. cit.

indicated that the KEPCO total of \$20 billion was 30% lower than the Areva bid, which in turn was lower than the GE-Hitachi offer.¹⁴ Another report described KEPCO's price as \$16 billion lower than Areva's.¹⁵ KEPCO's bid averages out to \$5 billion per reactor, which is higher than a reported estimate of \$3.15 billion for each of two APR-1400s being built at the Shin-Kori site in Korea, with the difference ascribed to the additional costs of operating in a country with no previous nuclear experience.¹⁶ The \$20 billion cost of 4,200 megawatts of electric generating capacity works out to \$3,571 per kilowatt, which is similar to the average of recent comparable U.S. estimates for new nuclear plants. (See CRS Report RL34746, *Power Plants: Characteristics and Costs*, by Stan Mark Kaplan.)

Korean and U.S. Partnership

As noted above, the Korean and U.S. companies involved in the UAE project have worked together extensively in the past on the domestic Korean nuclear power program, with Korean firms gradually taking over most of the work. Below are the members of the KEPCO consortium and their roles in the UAE project:

- *KEPCO*. Prime contractor and project integration. According to the ENEC announcement, "KEPCO is expected to begin mobilizing its team in Abu Dhabi immediately."
- *Korea Hydro and Nuclear Power Company (KHNP)*. Operating company for Korean nuclear power plants. To serve as engineering, procurement, and construction contractor and operator. KEPCO subsidiary.
- *KOPEC*. Nuclear power plant architect/engineering services. Majority owned by KEPCO.
- *Korea Nuclear Fuel Company (KNF)*. Initial nuclear fuel loads.
- *Korea Plant Service and Engineering Company (KPS)*. Plant maintenance.¹⁷ Majority owned by KEPCO.
- *Doosan Heavy Industries & Construction*. Fabrication of nuclear steam supply system and other major components.
- *Samsung C&T Corporation*. Plant construction.
- *Hyundai Engineering and Construction*. Plant construction.
- *Westinghouse Electric Company*. Technical and engineering support services and various components.
- *Toshiba Corporation*. Majority owner of Westinghouse. Role unspecified. Possible component supply and technical consulting.

¹⁴ Chris Stanton, "Nuclear Bid to Be Industry Norm," *The National*, December 28, 2009, <http://www.thenational.ae/apps/pbcs.dll/article?AID=/20091228/BUSINESS/712289928>.

¹⁵ Bakr, op. cit.

¹⁶ Stanton, op. cit.

¹⁷ "KEPCO to Provide Design, Construction and Maintenance of Nuclear Reactors," *Khaleej Times Online*, December 28, 2009.

Westinghouse has projected that its share of the contract will be as much as \$1 billion, or about 5% of the total, generating or sustaining several hundred U.S. jobs. Westinghouse has not released the specific scope of its activities under the contract, except that it may include the supply of plant components, man-machine interface systems, instrumentation and control equipment, and technical and engineering support services.¹⁸ The estimated Westinghouse share of the UAE contract is similar to its reported share of the construction of the two Shin-Kori APR-1400s, about \$300 million. Specific reactor components being provided by Westinghouse under the 2006 Shin-Kori contract include reactor coolant pumps and motors, reactor vessel internals, and control element drive mechanisms.¹⁹

Although most of the U.S. technology involved in the Korean standard reactor designs (OPR-1000 and APR-1400) has been successfully transferred to Korean firms as called for by the initial C-E licensing agreement in 1987, Westinghouse still considers the Korean reactors to be Westinghouse-licensed products. As a result, the UAE reactor sale will be subject to U.S. export control requirements.²⁰

Westinghouse is also partnering with Korean industry to produce control element assemblies for C-E reactor designs, including U.S. and Korean nuclear power plants, as well as the UAE plants and other potential Korean exports. The joint venture between Westinghouse and KNF is being located at the KNF fuel fabrication plant in Daejeon, Korea, and will be 55% owned by Westinghouse.²¹

Outlook for Korean Exports

The goal set by the Korean Ministry of Knowledge Economy for a 20% South Korean share of the global nuclear power plant market would place South Korea about equal to Russia and behind only France and the United States in the nuclear market, according to a ministry report to President Lee. “Nuclear power-related business will be the most profitable market after automobiles, semiconductors, and shipbuilding,” the report said. MKE also called for South Korean firms to expand their share of the estimated \$78 billion world market for operation, maintenance, and repair of nuclear power plants. MKE announced an interim goal of signing contracts to export six more Korean nuclear units, in addition to the four purchased by the UAE, by 2012.²²

The UAE contract added substantial credibility to MKE’s export goals and changed the dynamics of the world nuclear power market. Kuwaiti officials were paraphrased as saying the UAE price “is likely to become a benchmark for atomic energy technology across the region.”²³ After losing the UAE contract, Areva was reported to be examining ways to modify its plant design to cut

¹⁸ Lopatto, op. cit.

¹⁹ “Two New Nuclear Plants for South Korea,” *Nuclear Engineering International*, September 6, 2006.

²⁰ Lopatto, op. cit.

²¹ April Murelio, “Westinghouse, KNF Team to Manufacture Control Element Assemblies,” *Nuclear Power Industry News*, February 9, 2009.

²² World Nuclear News, op. cit.

²³ Stanton, op. cit.

costs, such as by cutting the number of steam generators from four to two by making them larger, as in the Korean design.²⁴

Other potential Korean export deals are under consideration in Indonesia and the United States, Westinghouse's home market. Other countries that have been mentioned in the news media include Vietnam, Malaysia, Thailand, and Middle East neighbors of the UAE.²⁵ A Korean consortium has reportedly been selected by Jordan to build the kingdom's first research reactor.²⁶ KNHP signed a preliminary agreement with Indonesian energy firm Medco Energi in July 2007 to build Korean-design reactors in Indonesia.²⁷ A feasibility study is currently underway for four OPR-1000 units that could begin operating by 2016.²⁸ However, Japanese firms are reportedly also under consideration.²⁹ A U.S. energy development company, Alternate Energy Holdings Incorporated (AEHI), announced in January 2010 that it was negotiating with South Korean officials on an agreement to build APR-1400 nuclear units at proposed sites in Idaho and Colorado. An AEHI news release said, "We expect the agreement to be similar to the UAE agreement announced last week. Such technology should give AEHI a serious competitive advantage."³⁰ Plans for financing for the proposed projects are unknown, however.

KEPCO took an early step toward exporting the APR-1400 to the United States by meeting with the U.S. NRC November 18, 2009, on possible standard design certification for the reactor. At the "initial pre-application meeting," KEPCO gave a presentation on the Korean nuclear industry, the U.S. and Korean work on developing the System 80+ and the APR-1400, and differences between the two designs. Prospects for NRC certification of the APR-1400 could presumably be helped by its similarity to the previously certified System 80+. However, NRC officials stressed that "this meeting did not initiate the review of the APR-1400 design certification and that staff resources for this review are not currently in the NRC budget for at least the next two years. Additional interactions with KEPCO regarding their plans are expected to occur in the future."³¹

The capacity of the Korean nuclear industry would apparently need to expand to meet MKE's export goals. As noted above, Korea has been completing an average of about one reactor every 16 months and plans to increase that rate to about one per year after 2021 for the domestic market. In addition, Doosan and other firms have been producing major reactor components for non-Korean reactors, such as the four Westinghouse AP-1000 units being built in China. To export 80 units by 2030, as implied by the MKE goal, the Korean industry would have to complete an additional four units per year, a substantial increase over the current rate. However,

²⁴ Ann MacLachlan, "Areva Considering Ways of Cutting Costs of EPR Nuclear Reactor," *Platts Commodity News*, January 11, 2010.

²⁵ Global Collaborative, "KEPCO/KHNP," <http://www.globalcollab.org/Nautilus/australia/reframing/aust-ind-nuclear/ind-np/muria/countries/kepc>.

²⁶ Taylor Luck, "S. Korea Bidder to Build Nuclear Research Reactor in Jordan," *Jordan Times*, April 12, 2009.

²⁷ "S. Korea, Indonesia Sign Nuclear Cooperation Deal," *Reuters*, July 25, 2007.

²⁸ World Nuclear Association, op. cit.

²⁹ Reuters, op. cit.

³⁰ Alternate Energy Holdings Incorporated, "AEHI Expects to Close Deal to Import Korean Reactors in Early 2010," press release, January 4, 2010, <http://www.alternateenergyholdings.com/LinkClick.aspx?fileticket=gVVisrNAzgl%3d&tabid=1979>.

³¹ Nuclear Regulatory Commission, *Korea Electric Power Corporation APR-1400 Presentation*, ML093430109, December 9, 2009, <http://adamswebsearch.nrc.gov/scripts/securelogin.pl>.

the total implied construction rate of about five units per year has been achieved by other countries in the past, such as France during the 1980s.³²

To expand Korea's nuclear plant construction and service capacity, MKE has announced plans to train 2,800 nuclear technical staff by 2011 and invest \$350 million in further design improvements, including an increase in research and development personnel. Under the MKE plan, South Korea would become completely self-sufficient in nuclear reactor technology by 2012.³³

U.S. Policy Considerations

The future direction of U.S.-South Korean cooperation in world energy markets poses a number of near- and long-term policy considerations for the United States. U.S. policymakers will face decisions related to U.S. nuclear energy cooperation with Korea that will affect broader U.S. policy goals. In turn, U.S. decisions based on broad policy goals will have an effect on Korean involvement with the U.S. nuclear industry.

The most immediate potential decision related to these issues will be the Secretary of Energy's judgment on whether to authorize Westinghouse and its employees and contractors to participate in the KEPCO reactor sale to the UAE. The so-called 810 Authorization, under Title 10, Part 810, of the U.S. Code of Federal Regulations, is required for any U.S. person to assist in the production of special nuclear materials (such as through construction and operation of a nuclear power plant) in another country. According to Westinghouse officials, "Westinghouse will submit the required application to the U.S. DOE for technology export authorization and Westinghouse will be involved in the project as the originator of the technology."³⁴

Section 810 implements Section 57b of the Atomic Energy Act (42 U.S.C. 2077), which also prohibits nuclear technology export to countries without an agreement for nuclear cooperation under Atomic Energy Act Section 123. Under Section 57b, the Secretary of Energy must determine that the proposed technology export "will not be inimical to the interest of the United States" with the concurrence of the Department of State and after consultation with NRC and the Departments of Commerce and Defense. The recently implemented U.S.-UAE 123 agreement excludes fuel cycle facilities, such as uranium enrichment and reprocessing plants, that could produce weapon-useable material. South Korea signed its own nuclear cooperation agreement with the UAE on June 22, 2009. (For more information about the U.S.-UAE 123 agreement, see CRS Report R40344, *The United Arab Emirates Nuclear Program and Proposed U.S. Nuclear Cooperation*, by Christopher M. Blanchard and Paul K. Kerr.)

Because of the restrictions in the U.S.-UAE 123 agreement, the 810 authorization for the South Korean reactors is likely to raise fewer issues than it might have otherwise. Nevertheless, the authorization will undergo a thorough interagency review relating to U.S. interests in the region and throughout the world, such as controls on the re-transfer of U.S.-origin nuclear technology

³² Arnulf Grubler, *An Assessment of the Costs of the French Nuclear PWR Program 1970-2000*, International Institute for Applied Systems Analysis, IR-09-036, Laxenburg, Austria, October 6, 2009, p. 8, <http://www.docstoc.com/docs/19721910/Interim-Report-IR-09-036-An-assessment-of-th>.

³³ World Nuclear News, op. cit.

³⁴ Lopatta, op. cit.

after it is exported by Korea. Future South Korean exports will be subject to similar 810 reviews as long as U.S. companies or individuals are involved.

The degree to which the United States retains control over the South Korean nuclear program has led to proposals for South Korean “nuclear sovereignty.” As reported in the Korean news media, the term has been applied to restrictions ranging from the current U.S. prohibition on South Korean spent fuel reprocessing to approvals of technology exports, such as the UAE sale. South Korean Minister of Knowledge Economy Choi Kyung-hwan recently clarified that the term does not refer to nuclear weapons development by using the phrase “peaceful nuclear sovereignty.” Choi called the current U.S. restrictions on Korean spent fuel reprocessing “excessive,” and pointed to the UAE sale as evidence of, as paraphrased in a Korean news report, “global confidence in South Korea’s ability to handle the task.”³⁵ KAERI is conducting a laboratory-scale research program on reprocessing spent fuel with an advanced pyroprocessing technique. However, the level of consensus over the pyroprocessing option among government agencies, Korean electric utilities, and the public remains uncertain.

The current U.S.-Korea 123 agreement prohibits South Korea from reprocessing any U.S.-origin spent fuel, including spent fuel from South Korea’s U.S.-designed reactors, without U.S. permission. KAERI’s pyroprocessing technology would partially separate plutonium and uranium from spent fuel, but the United States has not allowed the technology to be applied to actual spent fuel. The 123 agreement expires in 2014, and some South Korean officials have called for significant changes in the reprocessing restrictions, such as the granting of the advance approval already given to Japan and Western Europe. According to one Korean news account, the Korean reactor sale to the UAE “appears to have boosted efforts to seek a revision” of the U.S.-Korea 123 agreement.³⁶ Although the issue has the potential to become an irritant in bilateral relations between Washington and Seoul, thus far it appears to be a relatively minor one. As of early 2010, many experts contacted by CRS describe U.S.-South Korean relations as in their best shape in over a decade.

The United States and South Korea continue to cooperate on nuclear technology development in key international forums. Through the Global Nuclear Energy Partnership (GNEP), the United States, South Korea, and 23 other partner nations (plus 31 observers) are studying world needs for nuclear infrastructure development and reliable nuclear fuel supply, including reprocessing technology. The United States and South Korea are also founding members of the Generation IV International Forum (GIF), a cooperative international research effort on advanced nuclear reactor technology. Nuclear energy R&D was a high priority of the George W. Bush Administration. Under President Barack Obama, funding has continued for those efforts, although the programs have been refocused away from deployment and toward fundamental research. Recent U.S. news media reports have indicated that there may be disagreement within the Obama Administration over future funding for DOE nuclear energy R&D.³⁷

Future growth of South Korea’s nuclear energy technology export program would offer opportunities for the U.S. nuclear industry as well as significant challenges. As the KEPCO-UAE sale makes clear, U.S. companies can directly benefit from participation in Korean export projects, in this case an estimated \$1 billion for Westinghouse. But the UAE project also

³⁵ “Seoul Wants ‘Sovereignty’ in Peaceful Nuclear Development,” *Chosun Ilbo*, December 31, 2009.

³⁶ *Chosun Ilbo*, op. cit.

³⁷ George Lobsenz, “White House Moves to Restrict DOE Nuclear Research,” *Energy Daily*, January 15, 2010, p. 1.

illustrates the potential competition the U.S. nuclear suppliers may face from Korea, which overcame a GE-Hitachi bid in the final round and an earlier Westinghouse proposal. As the South Korean nuclear industry develops more reactor components of indigenous design, the opportunities for U.S. participation in South Korean export projects may diminish. Government ownership of KEPCO may also be a competitive concern for U.S. industry. A World Nuclear Association report notes that South Korea may develop a large, exportable reactor design based on the APR-1400 with indigenous components by 2015, “though Westinghouse is not likely to let it compete in main markets such as USA and China without KEPCO buying the rights to the design.”³⁸ Such issues related to South Korean “peaceful nuclear sovereignty” are likely to be a topic of continuing U.S.-ROK discussion.

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³⁸ World Nuclear Association, op. cit.