ROK-U.S. Civil Nuclear and Nonproliferation Collaboration in Third Countries

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CONTENTS

CHAPTER 1

Introduction

The United States and the Republic of Korea (ROK) have enjoyed a lengthy and fruitful bilateral cooperative relationship in the peaceful uses of nuclear energy and in promoting mutual nuclear nonproliferation objectives. The United States has long been a major exporter of nuclear materials, equipment, and technology. South Korea has recently entered the international nuclear market—for example, it has sold nuclear reactors to the United Arab Emirates (UAE)—and is positioning itself to become a leading supplier of nuclear reactors, components, and services to other countries. The nuclear industries of both countries are already closely intertwined.

The projected growth in the use of nuclear power worldwide creates new opportunities for deepening and expanding existing U.S.-ROK collaboration to promote the civil uses of nuclear energy in third countries.[1] This expansion can build on the cooperation that is already taking place. For example, American companies are participating in the South Korean-led nuclear project in the UAE, and South Korean firms are significant suppliers to Westinghouse AP1000 reactors that are under construction in China. The governments and nuclear industries of both the U.S. and the ROK also have a strong mutual interest in ensuring that their cooperation in transferring nuclear materials, equipment, and technology to third countries is subject to the strictest safety, security, and nonproliferation standards. The conclusion of a new ROK-U.S. civil nuclear cooperation agreement, which is expected soon, should help enhance nuclear commerce and intergovernmental collaboration between the two countries, and promote the development of partnerships between their industries in third markets.

The United States' nuclear exports to the ROK as well as U.S. cooperation with South Korea in the international market are governed by the U.S. nuclear export control system. U.S. nuclear cooperation with other countries is subject to a range of laws, regulations, and policies that are administered by various agencies of the U.S. government. This nuclear export control system applies to direct U.S. nuclear exports to South Korea; to the retransfer from South Korea of U.S.-origin nuclear materials, equipment, components, and technology to third countries; and to joint cooperation between U.S. and South Korean companies in the international market.

U.S. legal instruments for nuclear trade with cooperating partners as well as the specific nonproliferation assurances and controls required for particular exports vary, depending on the sensitivity of the material, equipment, or technology involved. In addition, U.S. law specifies the particular standards and criteria that must be met before various kinds of cooperation may be authorized.

This report attempts to answer a number of questions, including the following:

- What are the U.S. legal, regulatory, procedural, and policy requirements and criteria for collaboration with South Korea involving (1) direct exports from the U.S. to third countries; and (2) reexports by the ROK to third countries of U.S.-origin nuclear materials, facilities, components, and technology, as well as dual-use items?
- What kind of U.S. nuclear exports, or reexports from South Korea, to a third country would require that a U.S. peaceful nuclear cooperation agreement (sometimes called a 123 agreement) be in effect with that third country?[2]
- What kinds of nuclear items may be exported or retransferred without a peaceful nuclear cooperation agreement?
- When a peaceful nuclear cooperation agreement is not required, what kinds of legal instruments and nonproliferation assurances would the U.S. require of the third county? Of South Korea?
- How do the United States' nuclear export requirements differ from those of other major nuclear suppliers? To what extent will disparities in requirements between the U.S. and other suppliers affect competitiveness in the global nuclear marketplace and the prospects for U.S.-ROK collaboration in third countries?
- In what countries is South Korea seeking to promote its nuclear exports, and what are the prospects for such exports?
- What are the prospects for U.S.-ROK collaboration in third-country markets, given the relative strengths and weaknesses of their respective industries, while bearing in mind that American and South Korean companies may sometimes be in direct competition for nuclear projects in third countries?
- What steps could the U.S. government take to facilitate the two countries' collaboration in the international nuclear market?
- What cooperative steps could the governments and companies of the ROK and the U.S. take to ensure the establishment of the highest standards of nuclear nonproliferation, security, and safety in countries benefiting from U.S.-South Korean nuclear collaboration?

The remainder of this report is organized as follows:

Chapter 2 identifies the legal, regulatory, and policy requirements that are necessary to enable South Korean and American nuclear industries to cooperate in exporting U.S.-origin nuclear equipment, components, fuel, technology, and services to third countries. Collaboration between South Korean and U.S. companies may take many forms, including:

- Direct physical exports of nuclear materials, equipment, and components from the United States to South Korea or to a third country;
- The reexport of such U.S.-supplied items by the ROK to a third country;
- The transfer of nuclear technology from U.S. companies to South Korea or the retransfer of such technology by the ROK to a third country, which could involve such transactions as the provision of design information, person-to-person contacts, and consulting arrangements.

Because current South Korean power plants are largely derived from U.S.-origin technology, the United States is in a position to approve the conditions under which South Korean reactors and related technology are exported to third countries. This chapter examines the range of U.S. laws, regulations, and policies that apply to direct U.S. nuclear exports as well as reexports. In addition, it

describes the statutory standards and criteria that the U.S. would apply to the approval of U.S. peaceful nuclear cooperation agreements; to individual exports or reexports of nuclear material, facilities, equipment, components, substances, and know-how; and to dual-use items and technology.

Chapter 3 compares U.S. nuclear export requirements with those of other suppliers, and assesses whether and to what extent any differences may affect the ability of the United States to compete in the global nuclear market and to collaborate with South Korea in third-country nuclear projects. In making such assessments, it examines other factors, in addition to U.S. nuclear export controls, that might affect the competitive position of U.S. nuclear firms.

Chapter 4 examines the potential for, and obstacles to, South Korean exports to the existing or planned nuclear programs of other countries. In particular, it identifies those countries that are embarking on new nuclear programs, including countries in Central and Eastern Europe, Asia, and the Middle East that South Korea sees as likely prospects for its nuclear exports.

Chapter 5 examines the prospects for U.S.-ROK nuclear cooperation in third countries. It begins with a description of the existing nuclear ties between the two countries, and follows with an attempt to identify the strengths and weaknesses of the American and South Korean nuclear industries that might enhance the value of collaboration between the two countries. Its purpose is not to identify particular countries or projects as promising candidates for future cooperation between South Korean and American nuclear companies, because those are matters that the companies themselves will approach in light of their own commercial interests. Rather, it seeks to identify the overall comparative advantages and disadvantages of the American and South Korean nuclear industries, recognizing that such relative strengths and weaknesses could promote collaboration in some markets while giving one country an edge in competing for sales in other markets.

Chapter 6 describes the steps that the U.S. government might take to create a more promising framework for U.S.-ROK nuclear collaboration in third countries, including concluding new peaceful nuclear cooperation agreements or replacing existing agreements with countries that could be recipients of South Korean nuclear exports, implementing such pacts in ways to better facilitate nuclear trade, broadening cooperation in research and development, and improving America's own nuclear export procedures and capabilities.

Chapter 7 identifies the steps that the governments and companies of the ROK and the United States could take, either unilaterally or in collaboration, to ensure the establishment of the highest standards of nuclear nonproliferation, security, and safety in countries that might be the beneficiaries of U.S. and/or ROK peaceful nuclear cooperation.

Chapter 8 briefly summarizes the report's main points and conclusions.

CHAPTER 2

U.S. Legal and Policy Requirements for Nuclear Collaboration

The U.S. nuclear export control system is a complex set of laws, regulations, policies, standards, criteria, and procedures administered by several different departments and agencies of the U.S. government.

This chapter examines the U.S. legal, regulatory, procedural, and policy requirements for various forms of U.S.-ROK nuclear collaboration in third countries, particularly (1) direct exports from the United States to South Korea, (2) direct exports from the United States to third countries as part of joint U.S.-ROK collaboration, and (3) the exercise of so-called prior approval or consent rights for enrichment, reprocessing, and retransfers to third countries. It also describes the statutory standards that must be met before the U.S. government may authorize these actions and identifies the officials and agencies that must make those determinations.

U.S. law and policy have varying requirements and procedures for each of the following categories of nuclear and nuclear-related exports or retransfers:

- Nuclear facilities and their major critical components and nuclear materials;
- Other U.S. nuclear components and substances;
- Nuclear technology;
- Dual-use materials, equipment, and technology; and
- Items that are not on an export control list but that might be intended for nuclear explosive purposes, unsafeguarded nuclear activities, or sensitive nuclear activities.

Direct U.S. Nuclear Exports Requiring a U.S. Peaceful Nuclear Cooperation Agreement

Under sections 54 and 123 of the U.S. Atomic Energy Act (AEA), peaceful nuclear cooperation agreements (also known as 123 agreements) are required for only *two* categories of nuclear exports: "special nuclear material," and so-called production and utilization facilities and their major components.

a. Nuclear material

Special nuclear material is defined as plutonium, uranium enriched in the isotope 233 or in the isotope 235, or any other material that the Nuclear Regulatory Commission (NRC) determines to be special nuclear material. These are materials deemed most directly relevant for use in nuclear weapons.

In addition, since the enactment of the Nuclear Non-Proliferation Act (NNPA) of 1978, the U.S. government has consistently required that an agreement for cooperation be in place for any commercial exports of source material.[3] *(Source material* includes uranium, thorium, or any other material that the NRC determines by regulation to

be source material or ores containing one or more of the foregoing materials in such concentration as the NRC may determine from time to time.)

The United States requires special restraint on exports of highly enriched uranium (HEU)[4] and plutonium.[5]

b. Production and utilization facilities

1) The term "utilization facility" means any nuclear reactor other than one designed or used primarily for the formation of plutonium or U-233. An agreement for cooperation is required to export such a reactor and its major components—namely, pressure vessels, the primary coolant pumps, and the complete control rod system and, in the case of heavy water reactors, the fuel charging and discharging machines.[6]

2) The term "production facility" means:

   (a) Any nuclear reactor designed or used primarily for the formation of plutonium or uranium-233; or

   (b) Any facility designed or used for the separation of the isotopes of plutonium, except laboratory-scale facilities designed or used for experimental or analytical purposes only; or

   (c) Any facility designed or used for the processing of irradiated materials containing special nuclear material.[7]

The United States does not export nuclear production facilities.

Thus, in practice, a peaceful nuclear cooperation agreement between the United States and South Korea is necessary only for exports of:

- nuclear material,
- reactors,
- pressure vessels,
- fuel charging and discharging machines,
- complete control rod drive units, and
- primary coolant pumps.

Similarly, the retransfer of only these U.S.-supplied items from South Korea to another country would require the third country to have an agreement in force with the United States.

A peaceful nuclear cooperation agreement does not commit the United States to any specific exports or other cooperative activities, but rather establishes a framework of conditions and controls to govern subsequent commercial transactions. Exports under an agreement for cooperation would still require a license from the NRC; and the exercise of prior consent rights over enrichment, reprocessing, and retransfers would need authorization from the U.S. Department of Energy (DOE).

Legally Required Nonproliferation Assurances and Guarantees for U.S. Peaceful Nuclear Cooperation Agreements

Section 123 of the AEA requires that all U.S. peaceful nuclear cooperation agreement with non–nuclear weapon states contain several conditions, assurances, and controls. These include guarantees that:

- International Atomic Energy Agency (IAEA) safeguards on transferred nuclear materials and equipment as well as nuclear materials used in or produced through the use of such materials and equipment will continue in perpetuity, even if the peaceful nuclear cooperation agreement were to lapse or terminate for whatever reason.
- Comprehensive IAEA safeguards will be applied to all peaceful nuclear activities in non–nuclear weapon states.

- Nothing transferred may be used for any nuclear explosive device, for research on or development of any nuclear explosive device, or for any other military purpose, except in the case of military cooperation agreements with nuclear weapon states.
- The United States has the right to demand the return of transferred nuclear material and equipment, as well as any special nuclear material produced through their use, if the cooperating state detonates a nuclear explosive device or terminates or abrogates an IAEA safeguards agreement. This right of return is typically broadened in U.S. peaceful nuclear cooperation agreements to include other triggering events, such as a violation of the agreement.
- Material, equipment or components, or restricted data may not be retransferred without U.S. consent.[8]
- Physical protection on nuclear material is maintained. (In most agreements, this means adhering to the Convention on the Physical Protection of Nuclear Material (CPPNM) and/or to the IAEA Guidelines on Physical Protection, INFCIRC/225.) Most recent agreements provide for consultation and review of physical protection measures by the parties.
- The recipient may not enrich or reprocess or otherwise alter in form or content any transferred nuclear material or nuclear material produced with materials or facilities transferred pursuant to the agreement without prior approval of the United States.
- Storage of plutonium and HEU subject to the agreement must be approved in advance by the United States.[9]
- Any material or facility produced or constructed through the use of sensitive nuclear technology transferred under the cooperation agreement is subject to all the above requirements.[10]

Presidential Determinations and Congressional Review of Peaceful Nuclear Cooperation Agreements and Termination of Cooperation

Under the AEA, the president must submit the text of a proposed peaceful nuclear cooperation agreement to Congress for its review. The text must be accompanied by certain presidential findings. Before an agreement for cooperation may be signed and executed, the president is required to make the statutory determination that "the performance of the agreement will promote, and will not constitute an unreasonable risk to the common defense and security" of the United States. The secretary of state must also provide to the president an unclassified Nuclear Proliferation Assessment Statement that analyzes (1) the consistency of the text of the proposed agreement with all the requirements of the AEA, and (2) the adequacy of the safeguards and other control mechanisms and peaceful-use assurances contained in the agreement to ensure that any assistance furnished under the agreement will not be used to further any military or nuclear explosive purpose.

The proposed agreement must lie before Congress for its review for 90 days of continuous session before it may go into effect.[11] During that period, Congress may enact a resolution disapproving the agreement or approving it with conditions. Failing congressional action, the agreement may enter into force. However, if the proposed agreement does not include one or more of the guarantees and assurances specified in section 123 of the AEA, then the agreement must be approved by an affirmative vote of both houses of Congress.

These presidential determinations and congressional review procedures should apply to the new peaceful nuclear cooperation agreement between the United States and the ROK, and to other agreements that the United States may negotiate with other countries in the future. However, Congress has shown a growing interest in expanding its review and oversight of these agreements, and the

House Foreign Affairs Committee has passed a bill that would require, among other things, an affirmative vote of both houses of Congress if a future peaceful nuclear cooperation does not obligate the United States' trading partner to make a legal commitment to forswear enrichment and reprocessing capabilities.

Termination of cooperation. Section 129 of the AEA requires that no nuclear materials and equipment or sensitive nuclear technology shall be exported to countries if they are found by the president to have engaged in certain nuclear activities related to the proliferation of nuclear weapons.[12] Specifically, section 129 provides that no nuclear materials and equipment or sensitive nuclear technology shall be exported to:

(1) any non–nuclear weapon state that is found by the president to have, at any time after the effective date of this section (March 10, 1978)

(a) detonated a nuclear explosive device; or

(b) terminated or abrogated IAEA safeguards; or

(c) materially violated an IAEA safeguards agreement; or

(d) engaged in activities involving source or special nuclear material and having direct significance for the manufacture or acquisition of nuclear explosive devices, and has failed to take steps which, in the president's judgment, represent sufficient progress toward terminating such activities; or

(2) any nation or group of nations that is found by the president to have, at any time after the effective date of this section,

(a) materially violated an agreement for cooperation with the United States, or, with respect to material or equipment not supplied under an agreement for cooperation, materially violated the terms under which such material or equipment was supplied or the terms of any commitments obtained with respect thereto pursuant to section 402 (a) of the Nuclear Non-Proliferation Act of 1978; or

(b) assisted, encouraged, or induced any non–nuclear weapon state to engage in activities involving source or special nuclear material and having direct significance for the manufacture or acquisition of nuclear explosive devices, and has failed to take steps which, in the president's judgment, represent sufficient progress toward terminating such assistance, encouragement or inducement; or

(c) entered into an agreement after the date of enactment of this section for the transfer of reprocessing equipment, materials, or technology to the sovereign control of any non–nuclear weapon state except in connection with an international fuel cycle evaluation in which the United States is a participant or pursuant to a subsequent international agreement or understanding to which the United States subscribes.

The president may waive this section 129 requirement to halt cooperation if he or she determines that the cessation of such exports would be "seriously prejudicial to the achievement of United States non-proliferation objectives or otherwise jeopardize the common defense and security."[13]

Policy Requirements for U.S. Peaceful Nuclear Cooperation Agreements

In addition to the legal requirements described above for U.S. peaceful nuclear cooperation agreements, the U.S. has also included in its agreements for cooperation, *as a matter of policy*, several other provisions. These include:

- *Fall-back safeguards.* In the event that the IAEA cannot apply or is not applying safeguards, the United States has the right to apply bilateral safeguards.

- *Additional Protocol (AP) to the IAEA's safeguards agreements*. Recent U.S. agreements have included a requirement for the cooperating partner to have in effect the AP to their IAEA safeguards agreement. (The AP expands the IAEA's authority and practices to obtain increased information about, and access to, a state's nuclear activities and greatly enhances its ability to detect illegal, clandestine activities.)

- *Perpetuity of all nonproliferation assurances and controls*. Even if a peaceful nuclear cooperation agreement were to expire or terminate, all the nonproliferation assurances and guarantees contained in the agreement will continue in perpetuity. U.S.-obligated nuclear material will remain subject to these agreements until it has been retransferred to another party or until the material has been determined to be no longer usable for any nuclear activity relevant from the point of view of international safeguards.

- *Retroactivity of nonproliferation assurances*. The nonproliferation controls contained in post-NNPA agreements for peaceful nuclear cooperation (i.e., post-1978) apply retroactively to the nuclear materials and equipment covered by the previous agreements that they replaced. Therefore, nuclear material that had been subject to a previous agreement has become subject to the full panoply of assurances and controls of the new post-NNPA agreement.

- *Special controls on reprocessing and/or enrichment in regions of instability*. The U.S. imposed special constraints on enrichment and reprocessing in its agreements with two countries in the Middle East and with Taiwan. The 1981 U.S.-Egypt agreement for peaceful nuclear cooperation provides, among other things, that any reprocessing of U.S.-obligated nuclear material and any storage or fabrication of plutonium recovered as a result of such reprocessing will take place in facilities outside Egypt, and that the disposition of any resulting plutonium shall be subject to the mutual agreement of the parties. In the United States' peaceful nuclear agreements with the UAE and Taiwan, the UAE and Taiwan agreed not to possess enrichment and reprocessing facilities.[14]

Both the U.S.-Egyptian and U.S.-UAE agreements provide that the terms and conditions accorded by the United States to each of these countries for cooperation in the peaceful uses of nuclear energy shall be no less favorable in scope and effect than those that may be accorded by the United States to any other non–nuclear weapon state in the Middle East in a peaceful nuclear cooperation agreement.

These "most-favored-nation" provisions of the agreements with Egypt and the UAE would have relevance to any U.S.-ROK collaboration with countries in the Middle East, because they could affect U.S. negotiations of peaceful nuclear cooperation agreements with such states as Jordan and Saudi Arabia. The U.S. has been urging both these states to accept a legal commitment in any future peaceful nuclear cooperation agreement with the U.S. to abstain from acquiring enrichment and reprocessing capabilities.

Licensing Nuclear Exports under an Agreement for Cooperation

Peaceful nuclear cooperation agreements are not self-executing. Section 126 of the Atomic Energy Act stipulates that each export made pursuant to an agreement for cooperation requires a license from the NRC and must satisfy the U.S. nuclear export criteria set forth in sections 127 and 128 of the AEA.[15] Before issuing licenses for exports of nuclear facilities and special nuclear and source material, the U.S. obtains assurances that the recipient government will use the acquired items in accordance with the applicable peaceful nuclear cooperation agreement. The NRC is an independent agency of the U.S. government that cannot be required to issue a license by the executive

branch. At the same time, the NRC may not issue an export license until it has received a notification from the secretary of state that it is the judgment of the executive branch that the proposed export "will not be inimical to the common defense and security of the United States, or that any export in the category to which the proposed export belongs would not be inimical to the common defense and security because it lacks significance for nuclear explosive purposes."[16]

Section 126 of the AEA also provides that the secretary of state, in the event that he or she considers it warranted, may also address the following additional factors, among others:

- whether issuing the license or granting the exemption will materially advance the non-proliferation policy of the United States by encouraging the recipient nation to adhere to the Treaty (i.e., the Treaty on the Non-Proliferation of Nuclear Weapons); or
- whether failure to issue the license or grant the exemption would otherwise be seriously prejudicial to the nonproliferation objectives of the United States.

Nuclear exports from the U.S. to the ROK under a peaceful nuclear cooperation agreement would be subject to these licensing requirements.

Exercising Prior Consent Rights under Peaceful Nuclear Cooperation Agreements

As noted above, peaceful nuclear cooperation agreements accord the U.S. rights to approve reprocessing, enrichment, and the storage of plutonium and HEU as well as the retransfer of materials and equipment subject to the agreement. Section 131 of the AEA stipulates that approvals of such activities are so-called subsequent arrangements, and it sets outs certain procedures and criteria for considering requests for engaging in these activities.

Reprocessing and enrichment. Section 131 of the AEA provides that the secretary of energy may not approve spent fuel reprocessing or retransfers involving plutonium in excess of 500 grams unless, in his or her judgment and that of the secretary of state, such reprocessing or retransfer:

> *will not result in a significant increase of the risk of proliferation beyond that which exists at the time that approval is requested. Among all the factors in making this judgment, foremost consideration will be given to whether or not the reprocessing or retransfer will take place under conditions that will ensure timely warning to the United States of any diversion well in advance of the time by which the non–nuclear weapon state could transform the diverted material into a nuclear explosive device.*

After making these determinations, the secretary of energy must then submit a report to Congress containing his or her reasons for entering into such arrangement. A period of 15 days of continuous session must elapse before the approval may enter into effect.

Section 402 of the NNPA requires that the approval of enrichment of U.S. nuclear material subject to a U.S. peaceful nuclear cooperation agreement shall be subject to the same procedures and criteria set out in section 131 described above.

Retransfers. If South Korea wished to retransfer nuclear material or equipment subject to the U.S.-ROK peaceful nuclear cooperation agreement, it would have to obtain the consent of the U.S. government for the retransfer. Such consent would only be given if the recipient state agreed to place the item under its peaceful nuclear cooperation agreement with the United States. As noted above, approvals of such retransfers are subsequent arrangements and require the approval of the secretary of energy after he or she obtains the concurrence of the secretary of state, and consults with the NRC and the secretary of defense. The

secretary of energy must make a written determination that the proposed subsequent arrangement will not be inimical to the common defense and security.

Granting consent in agreements. In a few instances the U.S. has given consent to reprocessing and enrichment in a peaceful nuclear cooperation agreement itself rather than as a subsequent arrangement. But this has usually been the case only to countries that already possessed such capabilities. The U.S. gave advance consent to reprocessing and the use of plutonium in the European Atomic Energy Community (Euratom), Japan, and India. It also gave prior approval to the retransfer of U.S.-obligated spent fuel from Japan and Switzerland to Euratom for reprocessing, and the return of the recovered plutonium to those countries for use in their peaceful nuclear programs. More recently, the United States gave prior approval to the UAE and Taiwan to transfer U.S.-obligated spent fuel to Euratom for reprocessing in Euratom. In these latter cases, the U.S. retained a right to consent to the further disposition or retransfer of the recovered plutonium. The U.S. has also given consent to enrich uranium up to 20 percent in its agreements with Argentina, Australia, Brazil, Canada, Euratom, India, Japan, Russia, and Switzerland.

Nuclear Exports and Reexports That Do Not Require an Agreement for Cooperation

As described above, the export of nuclear materials, nuclear facilities, and their major components must be made pursuant to a peaceful nuclear cooperation agreement. Other nuclear components, items, and substances—such as fuel fabrication plants, uranium conversion facilities, deuterium or nuclear grade graphite, and other nuclear reactor components—must be licensed by the NRC but do not require an agreement for cooperation and are not made subject to a peaceful nuclear cooperation agreement with the recipient country. However, in considering the licensing of such items, the U.S. gives weight to whether the recipient country has in effect an agreement for cooperation with the United States, and exports of such items invariably go to states that have such agreements.

Direct Exports from the United States

The NNPA directed the NRC to determine which component parts and other items or substances will require export licenses because of their significance for nuclear proliferation, even if their export does not require a peaceful nuclear cooperation agreement to be in place. These components, substances, or items are identified in 10 *Code of Federal Regulations* (*CFR*) part 110.[17] Section 109 (b) of the AEA permits the export of such components only if the following criteria or their equivalent are met:

- *IAEA safeguards as required by article III.2 of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) will be applied with respect to the components, substances, or items;*
- *No component, substance, or item will be used for any nuclear explosive device, or for research on or the development of any nuclear explosive device; and*
- *No component, substance, or item will be retransferred to the jurisdiction of any other nation or group of nations unless the prior consent of the United States has been obtained for such a retransfer.*

The Department of State obtains a written assurance from the recipient government that it will adhere to these conditions before the export of any such item. The NRC must also determine that the licensing of such exports will not constitute an unreasonable risk to the common defense and security of the United States, and may not issue licenses for such exports if it is advised by the executive branch that the export would be inimical to the common defense and security.

These requirements would need to be fulfilled for the export of such components, substances, or items from the United States to South Korea or to

a third country in support of U.S.–South Korean collaboration on a nuclear project in that country.

Reexports from South Korea to a Third Country

If South Korea wished to retransfer one of these nuclear components or substances, it would need to obtain the United States' consent. The United States would grant its approval for such a retransfer only if the recipient government of the third country provided written assurances to the United States that the items proposed to be transferred will be used exclusively for peaceful purposes, subject to IAEA safeguards, and will not be retransferred to another country without the consent of the U.S. government. The recipient government would not, however, need to have a peaceful nuclear cooperation agreement with the United States.

In addition to the U.S. approval of the retransfer, the ROK would, of course, authorize the reexport of such items in accordance with its own national laws, regulations, and policies, and with the provisions of the Nuclear Supplier Guidelines.

Exports and Reexports of Nuclear Technology

In addition to tangible commodities, U.S. law applies to the transfer of information and services that might assist foreign nuclear programs—that is, nuclear technology. Specifically, section 57.b of the AEA requires prior approval of U.S. persons "to *directly or indirectly* engage or participate in the development or production of any special nuclear material outside of the United States." The terminology of this legal requirement is broad enough to cover such activities as the training of reactor operators (even in the United States) and assistance in designing foreign nuclear facilities.[18]

The transfer of nuclear technology to other countries may be approved in two ways:

1) as specifically authorized under an agreement for cooperation made pursuant to section 123 of the AEA, including a specific authorization in a subsequent arrangement under section 131 of the AEA; or
2) upon authorization by the secretary of energy after a determination that such activity will not be inimical to the interest of the United States.

The United States has exported nuclear technology under a peaceful nuclear cooperation in only one instance, namely in its agreement for cooperation with Australia for the transfer of SILEX enrichment technology.

Most nuclear technology exports have been subject to authorization by the secretary of energy under 10 *CFR* part 810, which implements section 57.b of the AEA.[19]

The part 810 regulation applies, but is not limited to, activities involving nuclear reactors and other nuclear fuel cycle facilities for the following: fluoride or nitrate conversion; isotope separation (enrichment); the chemical, physical or metallurgical processing, fabricating, or alloying of special nuclear material; production of heavy water, zirconium (hafnium-free or low-hafnium), nuclear-grade graphite, or reactor-grade beryllium; production of reactor-grade uranium dioxide from yellowcake; and certain uranium milling activities.

DOE has determined that transfers of certain technologies are generally authorized, (provided no sensitive nuclear technology is transferred) and, therefore, do not require a special authorization by the secretary of energy. These include information that is already in the public domain, along with information or assistance for radiological emergencies or to enhance the operational safety of an existing civilian nuclear power plant. Generally authorized technology transfers also include participation in programs of the IAEA or intergovernmental exchange programs, and open meetings that are sponsored by educational, scientific, or technical organizations or institutions.

However, certain kinds of assistance to foreign nuclear programs do require the secretary of energy's specific authorization. These are:

1) Assistance to enrichment, reprocessing, plutonium fuel fabrication, heavy water production, or research and test reactors above 5 megawatts (MW) (thermal) in any country. As a matter of policy, the United States generally does not export sensitive nuclear technology.20

2) Assistance to civilian nuclear power in countries on a list contained in section 810.8 CFR. This list presently contains 76 countries.

The ROK is not one of the countries on the section 810.8 list. Therefore, with the exception of sensitive nuclear technology, direct exports of nuclear technology from the United States to South Korea are generally authorized and do not require the special authorization of the secretary of energy. Thus, if a U.S. company such as Westinghouse Electric Company were to desire to export its reactor technology to the Korean Electric Power Company (KEPCO), the export of this technology to South Korea would be "generally authorized," and would not require Westinghouse to obtain a special authorization from DOE because the technology is not considered sensitive, and, as noted, because South Korea is not on the 810.8 list.

However, DOE's regulations oblige Westinghouse to require the South Korean company to obtain the consent of Westinghouse before it retransfers the technology to a third country. In other words, DOE holds Westinghouse responsible for complying with the part 810 rules, not KEPCO or the government of South Korea. In particular, DOE requires Westinghouse to have a contractual relationship in place with its partner, KEPCO, which obliges the South Korean company to obtain the approval of Westinghouse before approving a retransfer to a third country. Westinghouse must then follow the requirements of part 810 in considering KEPCO's request for the retransfer. Thus, the retransfer authorization process is implemented through the companies involved and the U.S. government and does not impose any obligations on the government of South Korea. Such retransfers from the ROK would, of course, need to be consistent with the ROK's nuclear export laws and regulations.

If the ROK were to wish to reexport U.S.-origin nuclear technology to any of the 76 countries on the 810.8 list, the retransfer would require the special authorization of the secretary of energy. The vast majority of these countries would not be likely candidates for nuclear cooperation with the ROK or the U.S. They include states that are not parties to the NPT, non–nuclear weapon states that do not have comprehensive safeguards agreements, countries that do not share the United States' nonproliferation objectives, and developing nations with no nuclear programs. The list contains three countries with major nuclear programs and that have agreements for cooperation with the United States—China, Russia, and India. Other countries that are on the 810.8 list that would be potential candidates for nuclear cooperation with the U.S. or the ROK are Jordan, Saudi Arabia, and the UAE in the Middle East as well as Vietnam. Exports or reexports of U.S. technology to these countries would presently require special authorization by the secretary of energy.[21]

It merits emphasis that, even if a transfer to a particular country requires a specific authorization, it does not mean that the transfer or retransfer of U.S.-origin technology to that country is prohibited. The secretary of energy would approve the transfer of technology to countries on this list by determining that the activity "will not be inimical to the interest of the United States." In making this determination, the secretary will take into account such factors as:

(1) Whether the United States has an agreement for nuclear cooperation with the country;

(2) Whether the country involved is a party to the NPT, or a country for which the Treaty for

the Prohibition of Nuclear Weapons in Latin America (Treaty of Tlatelolco) is in force;[22]

(3) *Whether the country has entered into an agreement with the IAEA for the application of safeguards on all its peaceful nuclear activities;*

(4) *Whether the country involved, if it has not entered into such an agreement, has agreed to accept IAEA safeguards when applicable to the proposed activity;*

(5) *Other nonproliferation controls or conditions applicable to the proposed activity;*

(6) *The relative significance of the proposed activity; and*

(7) *The availability of comparable assistance from other sources.*

(8) *Any other factors that may bear upon the political, economic, or security interests of the United States, including U.S. obligations under international agreements or treaties.*[23]

The U.S. has approved the transfer of technology to China and the UAE, two countries that are presently on the 810.8 list.

DOE is presently proposing changes to part 810 that, among other things, would increase the number of countries for which specific authorizations are required from 76 to 146. General authorization would apply to those countries that have an agreement for cooperation with the United States, with the exception of China, India, and Russia. The proposed new part 810 would add Kazakhstan, Ukraine, the UAE, and Vietnam to the generally authorized list of countries. The result of the proposed change would mean that:

- 44 major nuclear trading partners would remain generally authorized—and all these countries have peaceful nuclear cooperation agreements with the United States.
- 73 countries presenting proliferation issues would continue to require specific authorization.
- Russia, China, and India—even though they have peaceful nuclear cooperation agreements in effect with the United States—would continue to require specific authorization.
- Certain projects in Mexico and Chile would continue to be generally authorized.[24]

For the most part, the countries that would require a specific authorization from the secretary of energy under the proposed new regulation have little or no nuclear trade, have no peaceful nuclear cooperation agreement in place with the United States, or have no experience with managing proliferation issues. However, China, Russia, and India would continue to require specific authorization because of U.S. concerns that these countries do not adequately separate their civil nuclear activities from their military nuclear programs. In addition, the reporting requirements contained in the Hyde Act (which exempted India from the AEA's requirement for comprehensive safeguards), make it infeasible to grant India generally authorized status.

Exports and Reexports of Nuclear Dual-Use Items and Technology

Exports of dual-use items—items that have both nuclear and nonnuclear uses—do not require a peaceful nuclear cooperation agreement. Section 109 (c) of the Atomic Energy Act directs the Department of Commerce (DOC) to control all export items, other than those licensed by the NRC, which, if used for purposes other than those for which the export is intended, could be of significance for nuclear explosive purposes. Nuclear-related dual-use items can include such items as simulators, detectors, analytic equipment, and many types of pipes, valves, and other parts. DOC's Export Regulations and the Commerce Control List contain such dual-use items that require a license for export.[25] DOC must consult with the Department of State, Department of Energy, and the Department of Defense as well as the NRC before issuing licenses for dual-use items. Cases that draw no consensus or that raise

significant nonproliferation issues are referred for discussion to an interagency group (the Subcommittee on Nuclear Export Control). In 2014, DOC revised its Export Administration Regulations to implement the understandings reached at the 2005, 2012, and 2013 Plenary Meetings of the Nuclear Suppliers Group (NSG), and a 2009 NSG Intersessional Decision.

DOC implements its dual-use export controls by requiring the U.S. exporting company to obtain an end-use certificate from the importing country. DOC may, depending on the nature of the item to be exported and the country of destination or end user, impose a number of different conditions on the export, such as no military use, no nuclear use, no retransfer of the item without the consent of the U.S. exporter, and end-use checks.

If the ROK wished to retransfer a dual-use item obtained from the United States to a third country, it would need to obtain the consent of the United States government. It would, of course, need to abide by the provisions of its own nuclear export laws and the NSG guidelines for such retransfers.[26]

Catchall Controls

Even if an item to be exported is not on any export control list, its proposed exporter is required to apply for a license from DOC if the exporter knows that the item will be used for nuclear explosive activities; for unsafeguarded nuclear activities; or for safeguarded nuclear activities involving reprocessing, heavy water production, enrichment, or plutonium fuel fabrication.[27] The regulations governing so-called catchall controls are found in the Export Administration Regulations, Part 744.2.[28]

Standards and Criteria

U.S. law specifies various standards and criteria for approving U.S. peaceful nuclear cooperation agreements; issuing licenses for nuclear exports; approving retransfers of U.S.-obligated nuclear material, equipment, and technology; exercising consent rights; and licensing exports of dual-use items and other relevant materials, equipment, and technology. Some of these standards and criteria are specific, detailed, and well defined, and they are set out in sections 123, 127, and 128 of the Atomic Energy Act (AEA) for licensing nuclear exports—for example, guarantees of peaceful nonexplosive use, comprehensive safeguards, adequate physical protection, and prior consent rights to retransfers and to various sensitive activities. Other standards and criteria are expressed in broad stipulations, such as:

- Whether an agreement will promote and will not constitute a risk to the common defense and security, per section 123.c of the AEA.
- Whether a nuclear export will not "be inimical to the common defense and security," per section 126. A (1) of the AEA.
- Whether issuing the license or granting the exemption will materially advance the nonproliferation policy of the United States by encouraging the recipient nation to adhere to the Treaty (i.e., the NPT), per section 126a.1.A of the AEA.
- Whether failure to issue the license or grant the exemption would otherwise be seriously prejudicial to the nonproliferation objectives of the United States, per section 126 a.1 B; and
- Whether the approval of a request for reprocessing or retransfer for reprocessing "will not result in a significant increase of the risk of proliferation beyond that which exists at the time that approval is requested, per section 131." Section 131 of the AEA also adds: "Among all the factors in making this judgment, foremost consideration will be given to whether or not the reprocessing will take place under conditions that will ensure timely warning to the United States of any diversion well in advance of the time at which the non–nuclear weapon state could transform the diverted material into a nuclear explosive device."

How the executive branch has interpreted these standards may best be seen in the documentation—including Non-Proliferation Assessment Statements that the president, and the State and Energy departments, have submitted, along with proposed peaceful nuclear cooperation agreements, for congressional review. These documents usually base their judgments primarily on the relationship that the cooperation partner has with the U.S. and its nonproliferation credentials, including such factors as whether the cooperating partner adheres to and supports the various components of the international nonproliferation system, such as:

- The NPT or regional nuclear weapons free zone treaties;
- IAEA safeguards agreement and the AP to its IAEA safeguards agreement;
- Convention on the Physical Protection of Nuclear Material;
- International Convention on the Suppression of Acts of Nuclear Terrorism;
- Global Initiative to Combat Nuclear Terrorism;
- Proliferation Security Initiative;
- Participation in international nuclear export control mechanisms, such as those of the Zangger Committee (ZC) and the NSG, or adherence to their guidelines; and
- Implementation of an effective export control system.

In the case of the "timely warning" criteria for reprocessing, the executive branch of the U.S. government has taken the position that "a broad range of political, technical and other factors, including but not limited to safeguards and physical protection, can be relevant to detecting diversion and should be considered" in determining whether timely warning exists.[29]

CHAPTER 3

Comparison of the United States' and Other Major Suppliers' Nuclear Export Controls: Their Impact on U.S. Competitiveness

The United States has long had a reputation for its highly comprehensive, strict, and rigorous system for controlling its nuclear exports as a key component of its policy to prevent the proliferation of nuclear weapons. The prospects for peaceful nuclear collaboration between the ROK and the U.S. in third markets could be adversely affected if the comparative stringency and scope of U.S. export controls were to turn potential customers away from cooperation with the U.S. and the ROK to other nuclear suppliers, or if South Korean companies were to decline to collaborate with U.S. nuclear firms because they believed the strictness of U.S. nonproliferation policies would hurt the ROK's prospects with third-party customers.

This chapter attempts to compare the nuclear export polices of the United States with those of other suppliers and to assess the extent to which the comparatively strict U.S. export controls could harm the prospects for U.S.-ROK cooperation in competing in the global nuclear market. However, it bears emphasis that reaching confident judgments about these matters is difficult. For one thing, it is impossible to make a thorough comparison of U.S. nuclear export laws and policies with those of the other major suppliers. Although the U.S. publishes its export regulations and the texts of its agreements for peaceful nuclear cooperation, many suppliers do not make the texts of their peaceful nuclear cooperation agreements publicly available or do not publish them in English. Nor do other nuclear suppliers always reveal the specific nonproliferation undertakings they require or describe the precise way in which they implement them. Second, though the United States and the major suppliers adhere to the guidelines of the two multilateral nuclear control export mechanisms — the ZC and the NSG—these guidelines are voluntary. Some variation exists among members of the NSG because some states are not consistent in implementing or interpreting the multilateral guidelines. Because most U.S. nuclear export control requirements are set out in U.S. law, the U.S. must include the same basic assurances and controls in all its peaceful nuclear cooperation agreements and export licenses.

The Evolution and Harmonization of Supplier Export Policies

In the early days of the nuclear era, the United States was a monopoly supplier of nuclear materials, equipment, and technology. As other suppliers entered the market in the 1970s, many of them lagged significantly behind the United States in the nonproliferation conditions they imposed on their nuclear exports. This was particularly true in the 1970s and 1980s, when the United States took the lead in (1) requiring comprehensive safeguards as a condition of supply to non–nuclear weapon states, (2) imposing broad and restrictive consent rights over the enrichment and reprocessing of U.S.-supplied nuclear material, (3) restraining the transfer of sensitive nuclear technology, and

(4) imposing export controls on nuclear dual-use items and technology.[30]

With the exception of Australia and Canada, most other nuclear suppliers did not impose similar conditions on their nuclear exports. In some cases, these disparities clearly hurt American competitiveness in the international nuclear market. For example, when the United States made the acceptance of comprehensive IAEA safeguards a condition of supply to non–nuclear weapon states in 1980, U.S. nuclear cooperation with a number of states, including Argentina, Brazil, and India was cutoff. Other suppliers then took the place of the United States. During the late 1970s, the United States pursued a policy of strongly opposing reprocessing and the civil use of plutonium in all countries, and sought to use its prior consent rights to promote that objective. The delays and uncertainties in the United States' approval of requests for reprocessing and retransfers for reprocessing caused its foreign partners considerable problems in moving forward with their civil nuclear power programs and increased their costs of operation. As a result, some foreign utilities turned to non-U.S. sources for their uranium enrichment services as well as for other nuclear supplies.

However, over time, the disparities between the United States' nuclear export controls and those of other major supplier states have been greatly diminished. The bilateral controls of each individual supplier state were eventually supplemented by two internationally coordinated nuclear export control mechanisms.

The first is the so-called Zangger Committee (ZC), which was established in 1974 in order to implement article III.2 of the NPT. That article of the Treaty obliges states that are party to the NPT to require IAEA safeguards on their exports of nuclear materials and equipment. The ZC's members defined the specific nuclear materials and equipment that were only generally identified in article III.2 of the Treaty and placed these items on a Trigger List, so called because the export of listed items "triggers" certain conditions of supply, including the application of safeguards by the IAEA and peaceful, nonexplosive use assurances from recipient states that are not party to the NPT.

The second multilateral group is the NSG, whose guidelines were first published in 1978. The NSG adopted the ZC Trigger List of nuclear items, but also applied conditions to nuclear exports that went beyond the requirements of the NPT and ZC and added assurances of adequate physical protection and special restraints on the export of sensitive nuclear technology—that is, enrichment, reprocessing, and heavy water production technology. In many respects, the NSG has surpassed the ZC in importance as the more comprehensive of the two mechanisms.

Both these mechanisms have evolved over time in order to keep pace with technical innovations and political developments, and in response to various challenges to the nonproliferation system. The ZC has clarified and updated its nuclear Trigger List, and the NSG has followed suit. Today, their expanded lists are essentially the same.

Beginning in the early 1990s, the members of the NSG took key steps to strengthen and harmonize its nuclear export controls and to add controls on dual-use items and technology. In 1991 and 1992, the NSG adopted two important new guidelines. The first was the decision to include nuclear dual-use items and technology on its export control lists. The second was to require non–nuclear weapon state recipients to accept comprehensive IAEA safeguards as a condition of new supply of items on the Trigger List. In subsequent years, the NSG guidelines incorporated important new principles specifying that suppliers should be satisfied that their nuclear transfers do not contribute to the proliferation of nuclear explosives or to acts of nuclear terrorism. In 2004, the NSG adopted a catchall mechanism that called for each member to establish national laws and regulations to govern the export of items that are not on export control lists, in the event that such items are or may

be intended for use in connection with a nuclear explosive activity. In addition, the NSG adopted a guideline that provides for consultation in the event a customer state violates its nonproliferation commitments, as well as a provision for back-up or fall-back safeguards if the IAEA is not applying safeguards in a recipient country. Finally, both the ZC and the NSG have clarified, updated, and harmonized their nuclear Trigger Lists. The nuclear items and related technology on international control lists have been given more specific definition, and their number has increased significantly.

Today, all the major suppliers belong to either the ZC or the NSG.[31] With progressive expansion of membership and the clarification and addition of new conditions of supply to the guidelines of the ZC and the NSG, the principal nuclear exporting states have established widely agreed international norms for national export control systems. The conditions of supply set out in the NSG guidelines are broadly similar to the U.S. nuclear export controls described in the previous chapter, including peaceful, nonexplosive use assurances; comprehensive safeguards on nuclear exports to non–nuclear weapon states; consent rights; catchall controls; and provisions for the termination of cooperation and the return of supplied nuclear materials and equipment as well as controls on dual-use items.[32]

Differences Remaining between the United States and Other Nuclear Suppliers

As the discussion above has explained, in principle, all the major nuclear suppliers require nonproliferation controls and conditions on their nuclear exports similar to those of the United States. However, as noted above, the multinational mechanisms are voluntary, and variations exist among individual suppliers in their policies and practices and in their interpretations of the international guidelines.

In many cases, these differences should have little or no practical effect on the competitive position of the United States in the global market. The U.S. requires a number of nonproliferation conditions that most other states do not, but these differences thus far have not, and should not in the future, have a significant impact on the competitiveness of the U.S. in the international market. These include:

- All the nonproliferation controls and assurances contained in U.S. agreements continue in perpetuity, notwithstanding the termination or expiration of the agreement.
- The U.S. has also begun to require the AP as a condition of supply for its agreements.
- The grounds for the United States' termination of nuclear cooperation are more extensive than those set out by the NSG.
- The reasons for exercising the United States' right of return are much more extensive than those of the NSG.

However, certain key differences between the nuclear export policies of the United States and those of other suppliers have been cited as adversely affecting the competitiveness of U.S. companies, and, if such concerns are warranted, the differences could affect U.S.–South Korean collaboration in the global nuclear market:

- U.S. consent rights over reprocessing, enrichment and retransfers;
- U.S. policy on technology exports; and
- The complexities and inefficiencies of the U.S. export licensing and approval system.

Consent Rights for Reprocessing

Countries with existing nuclear power plants or states developing new nuclear programs place critical importance on suppliers exercising their prior consent rights over various aspects of their fuel cycle in a predictable and reliable manner. The development and utilization of nuclear energy require a large-scale investment of capital and other resources and long lead times. It would be difficult

for a country to develop nuclear power without a reasonable assurance that suppliers will not arbitrarily constrain or delay those programs. For the same reason, individual industries would hesitate to invest the billions of dollars that would be required to construct the necessary facilities without having adequate assurances from suppliers about whether and under what conditions a supplier will exercise its consent rights over key aspects of the fuel cycle. Thus, confidence in suppliers' reliability and predictability in these matters is essential for those countries that are dependent on or are interested in international nuclear cooperation. Changes in the policies of supplier governments or uncertainties related to their implementation can cause delays, inconvenience, and a financial loss for those engaged in the international nuclear trade.

As a study sponsored by the U.S. nuclear industry (hereafter, the Pillsbury Report) pointed out:[33]

> *In many instances, prospective purchasers of nuclear reactors, major components and nuclear fuel assign critical importance to such consent rights of the supplier nation. Such consent rights control the transfer of used fuel from the recipient country to third countries for storage, reprocessing or final disposition…Since countries that are establishing new nuclear power programs typically will not wish to construct expensive facilities for long-term storage or disposition of used fuel, they will likely need to export their used fuel for storage, reprocessing or final disposition. Accordingly, a supplier country's requirement that a recipient country obtain the supplier nation's consent is a very sensitive issue because recipient countries realize that their used fuel strategy could be disrupted by a failure to obtain supplier nation consent on a timely basis.*

Three aspects of U.S. policy on consent rights could place the U.S. at a competitive disadvantage in the international market:

1) Its reputation, gained largely from the 1970s, as an unreliable and unpredictable cooperating partner, particularly in the exercise of its consent rights;

2) The legally mandated character of U.S. consent rights; and

3) The greater strictness and breadth of U.S. consent rights compared with those of other suppliers.

Reputational problems. Unfortunately, the United States acquired a reputation as an unreliable cooperating partner in the 1970s when it sought to oppose civil reprocessing in all countries, including its allies, even after they had already constructed and begun to operate such facilities. The U.S. delayed giving its consent to reprocessing and retransfers for reprocessing, and then gave it only grudgingly. Despite this policy, there were few actual denials, and they caused delays and additional expenses rather than damage to nuclear programs. They did, however, cause nervousness and unease among the industry and consumer governments about the reliability of the U.S. as a cooperating partner, and caused some to turn to other suppliers. The U.S. sought to reestablish its reputation as a reliable supplier in the 1980s and 1990s by giving advance consent to reprocessing and enrichment to those cooperating partners that already had such capabilities, were close U.S. allies, and had excellent nonproliferation credentials—for example, Japan and Euratom—and that were located in areas of little proliferation concern. Washington gave similar advance consent to New Delhi in its 2008 agreement with India. Nevertheless, the United States' reputation during the 1970s still has reverberations today.

The mandatory nature of U.S. consent rights. As required by section 123 of the AEA, consent rights are included in all U.S. agreements. As one recent study published by the Center for Strategic and International Studies (CSIS) pointed out, when the NSG guidelines were being negotiated in the

mid-1970s, some states wanted the NSG to require consent rights over nuclear materials transferred or the materials produced therefrom.[34] However, there was strong opposition to making such rights mandatory. The negotiations produced a formulation that stated:

> *Suppliers recognize the importance, in order to advance the objectives of these guidelines and to provide opportunities further to reduce the risks of proliferation, of including in agreements on supply of nuclear materials or of facilities which produce weapons-usable material, provisions calling for mutual agreement between the supplier and the recipient on arrangements for reprocessing, storage, alteration, use, transfer or retransfer of any weapons-usable material involved.* ***Suppliers should endeavour to include such provisions whenever appropriate and practicable.*** (Emphasis added).

By contrast, U.S. law requires that all U.S. agreements for peaceful nuclear cooperation contain prior consent rights over:

- reprocessing and alteration in the form or content of U.S.-obligated nuclear material,
- storage of weapons-usable materials,
- the enrichment of U.S.-supplied nuclear materials, and
- the retransfer of nuclear materials and equipment subject to U.S. agreements.

As a result, supplier policies on consent rights vary. Only Australia, Canada, and the United States regularly require such consent rights over the nuclear materials they export subject to their bilateral agreements.[35] The Pillsbury Report concluded that "the U.S. is the only country of those surveyed (France, Japan, the Republic of Korea, Russia, and the United States) to consistently include the reprocessing consent provision in its agreements."[36]

Other states have different policies toward consent rights for reprocessing and alteration in form or content. Russia has been taking back spent fuel from its customers, but it is not known whether all Russian nuclear cooperation agreements contain explicit consent rights, as recommended in the NSG guidelines. In any case, a country's willingness to take back spent fuel from its customers is the equivalent of a consent right for reprocessing. This also gives Russia a clear competitive advantage over other nuclear suppliers.[37]

French agreements do not generally contain consent rights for reprocessing because French policy is to take back the spent fuel produced from French-supplied nuclear materials for reprocessing in France. (However, unlike Russia, France requires its customers to take back the plutonium, uranium, and high-level nuclear wastes recovered from reprocessing.) In its recently concluded agreement with New Delhi, Paris granted advance consent to reprocessing on essentially the same terms that Washington had approved for New Delhi's reprocessing of material subject to the 2008 U.S.-Indian agreement for peaceful nuclear cooperation.

Japan generally requires consent rights in its peaceful nuclear cooperation agreements.[38] South Korea requires consent rights for reprocessing in its agreements with some countries but not others. Reportedly, it does not require consent rights in its cooperation with "advanced nuclear states," such as Argentina, Brazil, Canada, China, France, Germany, Russia, and the United Kingdom.[39] The Pillsbury Report noted that the ROK included reprocessing consent language in its agreement with the UAE, but not in other publicly available bilateral agreements, such as its nuclear cooperation agreement with Argentina and its 2012 agreement with Japan.[40]

U.S. consent rights are stricter and more comprehensive than those of other suppliers:

- *U.S. consent applies to all future generation of plutonium*. The United States regards the

consent rights as applying to all future generation of plutonium used in or produced through the use of U.S.-obligated nuclear material and equipment. It is not known whether other suppliers regard their consent rights as applying to future generation of plutonium.

- *U.S. reprocessing consent rights are broader than those of other countries*. U.S. law requires the U.S. to have consent rights over the reprocessing of not only spent fuel produced from nuclear material transferred, pursuant to an agreement for cooperation, but also irradiated nuclear material "used in or produced through the use of nonnuclear material, nuclear material or equipment transferred pursuant an agreement."[41]

Consent Rights for Enrichment

Section 123 (a) (7) of the AEA requires a guarantee by the cooperating party that no U.S.-obligated nuclear material may be enriched without the prior approval of the United States. Some U.S. agreements give consent to enrichment up to less than 20 percent, whereas others require consent for any enrichment.[42]

The NSG guidelines have no provision for consent to the enrichment of supplied nuclear materials. Australia and Canada require consent for enrichment above 20 percent. Japan has reciprocal consent rights on enrichment (beyond 20 percent) in its agreements with the United States, Australia, Canada, and South Korea. In its agreement with Russia, Japan has consent rights over enrichment. Japan's agreements with Jordan and Vietnam prohibit them from enriching nuclear material subject to their individual agreements with Japan.[43]

Notwithstanding the various differences in the consent rights between the United States and other major suppliers, the more extensive and stricter nature of U.S. consent rights on reprocessing, storage of weapon-usable materials, and enrichment may not have as much adverse effect on countries' willingness to cooperate with the United States as they had in the past, for three reasons: (1) only a few countries have enrichment and reprocessing facilities, (2) newly emerging nuclear programs in the developing world have demonstrated little interest in acquiring such capabilities, and (3) the economic and fuel supply and fuel management cases for such fuel cycle facilities has not been proven, especially in countries with small nuclear energy programs.[44]

U.S. Retransfer Consent Rights

The NSG guidelines provide that suppliers should transfer Trigger List items and related technology only if (1) these items will not be used for nuclear explosive devices, (2) they will be placed under effective physical protection, and (3) the recipient state has a full-scope safeguards agreement with the IAEA. The NSG guidelines require suppliers to obtain the recipient's assurance that, in the case of retransfer of Trigger List items or items derived from them, the recipient of the retransfer will have provided the same assurances as those required by the supplier for the original transfer (i.e., peaceful use, physical protection, and IAEA safeguards).

The retransfer consent right found in U.S. peaceful nuclear agreements is broader than that found in the NSG guidelines because specific U.S. consent must be obtained for the retransfer of any material or item subject to the U.S. agreement. The Pillsbury Report concluded that the U.S. prior consent right for retransfer is more restrictive and burdensome than the NSG requirement because the latter specifies the types of assurances that are standard and not controversial.[45] The U.S. requirement to obtain supplier country approval, conversely, places the U.S. in a position to deny or delay such approval as it sees fit. It is noteworthy in this connection that the ROK, along with France and Japan, requires the same broad retransfer consent as does the United States. South Korea requires importing countries to provide a governmental assurance that reexports of ROK-controlled items will not

occur without an ex-ante (prior) request for approval from the ROK government.[46] Thus the U.S. and the ROK have the same and stricter retransfer consent rights as those set out in the NSG guidelines.

The Pillsbury Report reached the following conclusion regarding retransfer consent rights:

> *In many instances, prospective purchasers of nuclear reactors, major components and nuclear fuel assign critical importance to such consent rights of the supplier nation. Such consent rights control the transfer of used fuel from the recipient country to third countries for storage, reprocessing or final disposition.*
>
> *Since countries that are establishing new nuclear power programs typically will not wish to construct expensive facilities for long-term storage or disposition of used fuel, they will likely need to export their used fuel for storage, reprocessing or final disposition. Accordingly, a supplier country's requirement that a recipient country obtain the supplier nation's consent is a very sensitive issue because recipient countries realize that their used fuel strategy could be disrupted by a failure to obtain supplier nation consent on a timely basis.*

However, this conclusion is open to some reservations and questions. First, though countries with new nuclear programs may wish to export their used fuel to other countries for storage, reprocessing, or final disposal, they will find it difficult to identify a country that is willing to accept their used fuel for storage or disposal. Only Russia has expressed a willingness to accept spent fuel from other countries, but this policy applies only to used fuel produced from Russian-supplied nuclear material. Second, the U.S. has shown a willingness to give advance consent to some of its partners—for example, Japan, Switzerland, the UAE, and Taiwan—to retransfer U.S.-obligated used fuel to Euratom for reprocessing. Third, such retransfers to France and the U.K. do not solve the nuclear waste management challenges of countries just starting their nuclear programs, because both Paris and London require that the plutonium, uranium, and high-level waste recovered from reprocessing be returned to the country of origin.

Moreover, the U.S. has shown a willingness to give advance consent to retransfer nonsensitive materials, equipment, and components to third countries with which the U.S. has an agreement for cooperation—for example, the U.S. gave such consent to Euratom. It has also given advance approval in some cases—for example, the UAE and Taiwan—to transfer U.S.-obligated spent fuel to Euratom for reprocessing, which would reduce the perceived need to reprocess indigenously.

Hence, it is not at all clear that U.S. retransfer consent rights are likely to be a major impediment to U.S. competitiveness in the international market.

Cumbersome and Inefficient Regulations on Nuclear Technology Exports

The U.S. nuclear industry has long argued that U.S. nuclear export controls, particularly over technology transfers and retransfers, have placed U.S. companies at a competitive disadvantage in the international market. In particular, U.S. industry regards part 810 specific authorizations for technology transfers and retransfers as an impediment to competitiveness, and has registered concerns about the regulation's overly broad scope, lack of clarity and predictability, and outdated provisions. In addition, industry has expressed concerns about the protracted period of time required by DOE to process applications for specific authorization.

The Pillsbury Report concluded that the U.S. export control system is complex and difficult to navigate, evidenced by the division of export licensing and authorization powers among four agencies, versus one or two at most in other nations, and by

inefficient U.S. processing of export licenses, often taking nearly a year or more, compared with far faster processing in other nations. In comparing the export regimes of France, Russia, Japan, and the ROK with that of the United States, that study stated:

> *Whereas most of these regimes provide for a single export licensing agency to handle exports of nuclear commodities and technology, U.S. control of such items is divided among . . . DOE, the Department of State, . . . DOC, and the . . . NRC—which administer four very different sets of regulations, coupled with a complex interagency review process. For U.S. exporters and their customers, navigating the bureaucratic maze for a U.S. export license presents a challenge in itself that has no parallel in the other countries surveyed in this study.*

The report also said that compared with the foreign systems reviewed, the U.S. system imposes few deadlines for decision-making on export license applications. Although the AEA requires the NRC to process export license applications "expeditiously" and to endeavor to complete action within 60 days after the executive branch recommends that the license be issued, the consequence of missing this deadline is mainly that the applicant must be informed of the reason for the delay. The time consumed by DOE in processing applications for a specific authorization to export nuclear technology and provide nuclear technical assistance to foreign entities ranges from six months to well over one year. The NRC usually requires a year or more to process license applications for initial exports of reactors, major reactor components and nuclear fuel, and approximately nine months for applications for subsequent exports.

Interviews by the authors of this report with U.S. industry sources revealed complaints that the part 810 approval process is so onerous and time-consuming that some U.S. firms have lost out on foreign sales. South Korean industry representatives also complained to the authors that the U.S. is slow in approving requests for reexports.

The U.S. industry believes that an efficient and expeditious part 810 process is particularly important because it is necessary for U.S. companies to build the groundwork for hardware sales. The U.S. has to be on the front-end of projects, such as engaging in the activities covered by part 810, or it will lose out on sales of nuclear equipment. Although exports of hardware may take place only after a peaceful nuclear cooperation agreement is concluded, the part 810 process can and, in the industry view, should precede this in order to lay the groundwork for sales of hardware.

The U.S. Government Accountability Office (GAO) issued a report in 2010 that, in many respects, reiterated these concerns. The report stated:

> *U.S. industry representatives and U.S. foreign government officials GAO interviewed identified challenges that, in their view, impede the U.S. nuclear industry's ability to compete globally for nuclear trade, including a DOE process for authorizing the transfer of U.S. nuclear technology and technical information overseas. In particular, industry representatives told us that they believe that DOE regulations are outdated and place U.S. companies at a competitive disadvantage.*

The GAO also reported that a senior foreign-country official told GAO that the U.S. government's inability to work cooperatively had influenced that country's decision to purchase civilian nuclear power reactor fuel from a non-U.S. supplier.[47]

An October 2014 GAO report highlighted the slowness and inefficiencies of the part 810 review process.[48] That report concluded that DOE has consistently missed its 30-day target dates for the initial and interagency stages of this process. From 2008 through 2013, DOE missed the target for 80 of 89 of the applications it processed, and

interagency review times missed DOE's 30-day target for 85 applications.

The GAO 2014 report also concluded that:

> *The scope of Part 810 is unclear, and DOE's inquiry process does not reasonably assure that the regulation is consistently interpreted. For example, it is unclear what marketing activities are covered by Part 810. DOE has not provided written guidance to clarify the regulation's scope, instead directing exporters to inquire with DOE officials. DOE officials said that they do not document all such inquiries or their responses. Without such documentation, DOE can neither reasonably assure that its responses are consistent, nor can it analyze the inquiries to identify parts of the regulation that may need clarification. DOE is taking some steps to clarify Part 810, defining or refining some key terms. However, DOE's revisions do not address all terms that exporters haveidentified as unclear, and the time frame of DOE's revisions is unknown.*

Both U.S. and South Korean industries have also complained about lengthy delays in the U.S. government's negotiation of peaceful nuclear cooperation agreements, thus allowing foreign competitors to enter the market before U.S. companies are able to export nuclear equipment and materials.

Efforts to Require Cooperating Countries to Abstain from Enrichment and Reprocessing

One proposed change to U.S. law or policy that has been under discussion for some time in Washington could have serious adverse effects on the competitiveness of U.S. industry in the international market. This issue has concerned a debate between Congress and the administration, and between executive branch agencies over the issue of whether the U.S. should require new nuclear cooperation agreements to contain a legally binding pledge by cooperating partners to forswear the acquisition of enrichment and reprocessing capabilities. The United States' 2009 agreement for cooperation with the UAE contained such a commitment. In 2012, the House Foreign Affairs Committee unanimously adopted a bill that would require such a condition in all future U.S. agreements, with the stipulation that any agreement submitted to Congress without this provision would require an affirmative vote by the two houses of Congress. The committee reintroduced the same bill in 2013, but it has not passed either house of Congress.

The administration eventually decided to adopt a case-by-case approach toward this issue, whereby the U.S. would press future partners, except for the ROK and the IAEA, to make a legal undertaking to refrain from enrichment and reprocessing but would not necessarily walk away from an agreement if the other country refuses to accept this condition.

This case-by-case approach is evident in three recent agreements. The U.S. concluded an agreement with Taiwan that contained a binding commitment by Taipei that it would not acquire enrichment or reprocessing capabilities. In contrast, the administration sought a compromise formula in the recently concluded agreement for peaceful nuclear cooperation with Vietnam. That agreement contained no legally binding commitment on enrichment and reprocessing. Instead, in the agreement's preamble, Vietnam affirmed its intent "to rely on existing international markets for fuel services rather than acquiring sensitive nuclear technologies." In other words, Vietnam made a political commitment. The agreement also affirmed the intent of the United States to support those markets in order to secure a reliable nuclear fuel supply for Vietnam. The new U.S. agreement with the IAEA also contained no commitment to forswear enrichment and reprocessing.

At the same time, the U.S. is insisting on a legally binding pledge of no enrichment and reprocessing from countries in areas of instability or proliferation concern, such as the Middle East.

Despite the case-by-case approach that the administration has adopted, many in Congress and the U.S. nonproliferation community remain committed to enacting legislation that would require a pledge of no enrichment and no reprocessing in all future U.S. agreements. There may be special cases where such a pledge would be appropriate—for example, in regions of instability and/or proliferation concern. In addition, some potential partners will have political and strategic reasons for concluding a peaceful nuclear cooperation agreement with the United States, and they may well be willing to provide some form of commitment to abstain from enrichment and reprocessing, especially if they see little practical nuclear energy need to acquire fuel cycle capabilities in the foreseeable future.

However, adopting such a requirement for all future nuclear cooperation agreements would seriously threaten the prospects for concluding new peaceful nuclear cooperation agreements, because most countries regard access to such technology as their right under the NPT, even though the Treaty does not recognize the right to a particular technology. Moreover, any attempt by the U.S. to impose this requirement will lead many states to other suppliers that do not require a similar pledge as a condition for their nuclear exports.

Observations, Caveats, and Conclusions

Although the United States' nuclear exports may suffer because of the strictness of some of its export controls and the inefficiencies of its export control system compared with that of other nuclear suppliers, it is difficult to determine with any confidence whether and to what extent such disparities affect the decisions of buyers to favor other suppliers over U.S. nuclear exporters, relative to other factors.

The 2010 GAO study confirmed in its interviews with U.S. industry representatives that, in their view, several factors impede the ability of U.S. industry to compete globally for nuclear trade, including the DOE part 810 requirement for authorizing transfers of U.S. technology and material, a decline in domestic manufacturing capabilities, increased international competition, and the U.S. industry's liability concerns. The GAO study stated that the DOC reported in January 2010 that the U.S. nuclear industry had atrophied, and according to U.S. government officials and nuclear industry representatives, may lack the capability to manufacture certain components and equipment needed to produce large civilian power reactors.[49]

The 2010 GAO report noted that since the 1980s, other suppliers have emerged in the international market, including Canada, France, Japan, and Russia. Russian officials told the GAO that their Ministry of Foreign Affairs is aggressively seeking to sign as many nuclear cooperation agreements as possible, with an eye on expanding into new nuclear markets.

Another factor that puts U.S. nuclear companies at a competitive disadvantage is the strong financial and political support that foreign companies receive through direct government ownership or subsidies. Foreign governments may also place great emphasis on supporting bids through high-level advocacy or by providing customers with additional services and expertise. The GAO cited media reports that the president of France and the president of South Korea had traveled to the UAE to advocate for their country's respective bids to build new reactors in the UAE. In addition, French officials told the GAO that their government's philosophy on nuclear cooperation includes providing a package of regulatory, financial, and technical assistance to partner countries that are developing their own civilian nuclear power programs.

By contrast, what financial support the U.S. nuclear industry does receive is from the Export-Import Bank of the United States (Ex-Im), and that is limited. Financial support for U.S. nuclear exports has long been controversial. More important, Ex-Im now faces the possibility of extinction; its charter faced expiration on September 30, 2014, and its

reauthorization became a divisive issue among Republicans. Congress' Tea Party members (Republicans with a strong anti-tax and anti-government ideology), along with other conservatives in the House of Representatives, called for the abolition of Ex-Im. But just before adjourning in September, Congress was able to pass a bill that extended Ex-Im's life until June 30, 2015. The next Congress will need to decide whether to extend its life permanently or for a specified period, or to abolish it altogether. The uncertain status of the bank leaves the U.S. industry at a disadvantage compared with other suppliers because its potential customers will not know whether to expect financing.

According to the 2010 GAO report, some of the largest markets for nuclear goods and services—such as France, Russia, and South Korea—have significant barriers to entry for U.S. companies because of the presence of a state-owned competitor. The report indicated that, according to DOC, of the 61 civilian nuclear reactors outside the United States that began operating from 1994 through 2008, 18 reactors—almost 30 percent—went into operation in France, Russia, and South Korea—countries with their own state-owned nuclear companies.

The 2010 GAO report concluded that the absence of a comprehensive global liability program also hampers the U.S. industry's ability to secure civilian nuclear contracts, and that U.S. firms fear that they may be held liable as suppliers. By contrast, foreign companies that are state-owned may not face the same problem because they may be indemnified by their government. In the absence of a global liability regime, U.S. industry cannot obtain insurance sufficient to cover liabilities resulting from a potential nuclear reactor accident overseas.

Other studies have confirmed the GAO's observations and have pointed to factors that can affect U.S. competitiveness, including:

- the fact that the emergence of other suppliers long ago undermined the monopoly of supply that the United States enjoyed in the early days of nuclear energy. This was an inevitable development, and the future is likely to see the arrival of even more suppliers.
- the fact that the international playing field is not level. The nuclear export industries of other major suppliers have strong governmental and financial support that the U.S. nuclear export industry does not enjoy.
- the fact that the United States has not built new domestic nuclear power plants in over 30 years. Countries seeking to develop nuclear power are likely to turn for assistance to those states that have growing domestic nuclear power programs, offer competitive fuel cycle services, and support the development of advanced technologies. Although U.S. skills in operating and regulating nuclear power plants are highly valued, manufacturing and construction effectiveness (which brings down costs) do not have the reputation they once had.

Thus, it is difficult to determine the degree to which comparatively strict U.S. nuclear export controls affect the United States' competitiveness in the global market. There are anecdotal reports that some prospective customers of U.S. uranium concentrates, uranium hexafluoride (UF6), enriched uranium, and fabricated fuels as well as major reactor components have turned away from U.S. supply because of concerns about U.S. consent rights that attach to reprocessing or retransferring U.S.-obligated spent fuel. However, there are no citations or documentation that confirm actual cases of a country selecting other suppliers over the U.S. due to consent rights or other nonproliferation controls.

Moreover, other factors may favor the United States over its international competitors. The close political and strategic relationship that the U.S. enjoys with a number of countries may lead them to select U.S. vendors rather than others. In addition, the U.S. enjoys a reputation for the quality of its advanced nuclear technology, particularly its

safety systems, that could lead foreign utilities to prefer U.S. technology over other vendors. For example, though China is purchasing nuclear technology from a number of foreign suppliers, Beijing has made the Westinghouse AP1000 "the main basis of technology development."[50]

Although the U.S. may have stricter nonproliferation requirements than many other suppliers, this difference has not prevented the U.S. from concluding agreements with 19 individual countries, Taiwan, and two international organizations, including Euratom and its 28 member states.

Finally, precisely because of the strict nature of U.S. nonproliferation requirements, some countries are interested in concluding peaceful nuclear cooperation agreements with the United States because they view the United States' willingness to conclude such an agreement as a validation of their nuclear nonproliferation credentials.

Thus, it is difficult to point to specific cases where the U.S. has lost out on recent export sales because of its comparatively stricter nonproliferation conditions, because many factors go into a decision to purchase nuclear material and facilities, including the political relationship between the exporting and importing states, the quality of the technology, the different layers of financial and diplomatic support that governments provide to their nuclear export industries, and the presence or absence of an effective liability regime.

What seems clear is that the competitiveness of the American nuclear industry in the global market is adversely affected by the lack of clarity, the slowness, and the inefficiency of the U.S. export approval process, particularly the handling of requests for technology exports and reexports. South Korean officials have complained about the slowness of U.S. approval of reexports.

Notwithstanding the widespread dissatisfaction with the part 810 approval, it has apparently not caused great harm to U.S. nuclear exports to South Korea, or to the ROK's retransfers of U.S.-origin technology to third countries. As noted in the previous chapter, DOE is in the process of updating its part 810 regulations, and this will hopefully respond to most of industry's concerns, while at the same time, protecting U.S. national security interests. Whether the new regulations will achieve these objectives remains to be seen.

It also appears clear that any attempt by the U.S. to impose an overly rigorous pledge of no enrichment and reprocessing from future cooperating partners could undermine prospects for nuclear cooperation with those countries. This has become a significant issue in U.S. efforts to conclude agreements with Jordan and Saudi Arabia (See chapter 6). In the future, South Korea will need to evaluate these various factors in assessing the pros and cons of collaboration with the U.S. in individual third-country markets.

CHAPTER 4

Potential Markets for South Korean Nuclear Exports

The ROK's winning of the $20.4 billion bid to build four APR1400 reactors in the UAE by KEPCO—South Korea's national nuclear power plant supplier—has demonstrated the capabilities of South Korea's nuclear energy industry, and has increased the opportunities for the country's companies to compete in the global market.[51] In 2010, the South Korean Ministry of Knowledge Economy (now the Ministry of Trade, Industry, and Energy) stated that it aimed to achieve exports of 80 nuclear power reactors worth $400 billion by 2030, in the course of becoming the world's third-largest supplier of such technology, with a 20 percent share of the world market.[52] However, certain events over the last few years may force South Korea to lower its ambitious objectives. These include the Fukushima nuclear disaster in Japan, the discovery in 2012 that the safety certificates for parts of some of South Korea's reactors had been forged, and the temporary shutdown of two reactors in October 2012 after malfunctions and corruption charges that were leveled at employees of the state nuclear power agency earlier in 2014.[53]

Despite these problems, the International Energy Agency's *World Energy Outlook 2014* report notes that nuclear power is one of a limited number of options available at scale to reduce carbon dioxide emissions, and it projects that installed nuclear capacity will increase significantly globally by 2040, but that this growth would be concentrated in just a few countries. China, India, South Korea, and Russia will likely see the most significant increases in installed nuclear capacity. The projected increase in China of 132 gigawatts (GW) exceeds the current installed capacity of the United States and Russia combined. India's and Russia's nuclear power capacities will increase by 33 GW and 19 GW, respectively, and South Korea's will more than double, to 49 GW.[54]

Though it has moderated its ambitious nuclear export objectives, Seoul remains intent on competing for nuclear projects in a number of countries, including India, Vietnam, Indonesia, Poland, Jordan, Saudi Arabia, Turkey, South Africa, and China.[55] South Korea has signed nuclear cooperation agreements with 27 states and has provided training programs for countries that plan to launch new civil nuclear programs. According to the World Nuclear Association, in addition to exporting reactors, South Korea plans to enter the $78 billion market for the operation, maintenance, and repair of reactors.[56]

Potential Markets in Asia

China. China is in the middle of a huge nuclear reactor building program. According to recent reports, Chinese leaders have begun accepting the industry's consensus to rapidly develop nuclear power.[57] The State Council published the *Energy Development Strategy Action Plan, 2014–2020* on November 19, 2014, which calls for reducing China's dependence on coal and promoting the use of clean energy. The plan calls for China's current

19.1 gigawatts-electric (GWe) of installed nuclear generating capacity to increase to 58 GWe by 2020.

Whether this is a realistic target remains to be seen. One nuclear expert, Li Ning, dean of the School of Energy Research at China's Xiamen University, questions whether China can meet this target because the government still has not approved any new projects and will not approve too many at the same time because it will create bottlenecks. New construction projects are unlikely to speed up until the third-generation AP1000 reactor—which forms the basis for China's reactors—goes into operation at the end of 2015. Meeting the 2020 target of 58 GW would require around 40 reactors to enter operation in the next six years—a task already thought to be beyond China's capabilities. Assuming the 28 GW now under construction is completed in time, China would need to approve and build another 12 reactors quickly if it is to have any hope of hitting 58 GW by 2020.[58]

China also plans to have a further 30 GWe or more of new nuclear generating capacity under construction by 2020. The plan calls for the timely launch of new nuclear power projects on China's eastern coast and for feasibility studies for the construction of inland plants. China will focus its efforts on promoting the use of large, pressurized-water reactors (including the AP1000 and CAP1400 designs); high-temperature, gas-cooled reactors; and fast reactors.[59]

Realizing its civil nuclear power ambitions will require China to greatly increase its institutions for education and training to produce the engineers and skilled trades necessary to build and operate the plants. In addition, although China is headed toward self-sufficiency in reactor component manufacturing, it has suffered problems with the quality of parts and with systems integration during plant construction. The construction of new reactors projected in the energy plan will need a major boost in nuclear reactor pressure vessel foundry capacity, and also in the manufacturing of steam generators and turbines. China will need to significantly ramp up its nuclear safety and regulatory agency, and exercise independent authority over plant design, construction, and operation.[60]

China has become largely self-sufficient in reactor design and construction, as well as other aspects of the fuel cycle, but is still making full use of Western technology while adapting and improving it. China has acquired technology from France, Canada (including four CANDU reactors), and Russia. Its latest technology acquisition has been Westinghouse technology from the United States. China is basing its technology development for the immediate future on the Westinghouse AP1400, particularly with the local development of CAP1400, which is based on that technology.[61]

Westinghouse is building four AP1000 nuclear plants in China—two in pairs at Sanmen, and two at Haiyang. These plants represent the country's first construction of advanced U.S. nuclear plants.[62] The role of Westinghouse in the construction of these plants is significant. Westinghouse and Shaw CBI have complete responsibility for the scheduling and the technology for units 1 and 2 at each site. Westinghouse is also responsible for the technology at the second of two plants at each site. It supplies major components, equipment, and engineering to the nuclear island. Westinghouse and Shaw CBI also have significant "execution" responsibility for the nuclear islands for all four reactors. Westinghouse is taking advantage of the experience it gained in building reactors in South Carolina and is applying it to the Chinese situation.

Westinghouse is also in negotiations to build eight additional AP1000s at coastal sites in China, and in July 2014 the company and China indicated that they intend to build 26 of the company's AP1000 reactors at inland sites in China for an estimated $20 billion.[63]

Westinghouse has agreed to transfer technology to China for the first four AP1000 units so that China can build the following ones on its own. In 2014, China signed an additional agreement with

Westinghouse to deepen cooperation in relation to AP1000 and CAP1400 technology globally.[64] In September 2014, Westinghouse signed two agreements with China's State Nuclear Power Technology Corporation (SNPTC) for the supply of instrumentation and controls (I&C) systems. The first agreement extends an I&C systems cooperation agreement signed in November 2010 with China for AP1000 nuclear plant I&C systems. The extension covers the strategic relationship of Westinghouse and China's State Nuclear Power Automation System Engineering Company in supplying I&C systems for AP1000 new plant projects into the future. The second agreement covers I&C systems for future global SNPTC nuclear power plant projects, using designs derived from the AP1000 design by SNPTC.[65]

South Korea is also playing an important role in Westinghouse's sales to China. South Korea's Doosan Heavy Industries & Construction has partnered with Westinghouse to supply two pressure vessels and four steam generators for the two AP1000 nuclear power reactors it is constructing in China.[66] Doosan delivered the Sanmen 1 reactor pressure vessel, which arrived on site in July 2011. The pressure vessels for the other two units are being made by Chinese manufacturers. China First Heavy Industries (CFHI) has successfully completed the manufacture of the reactor pressure vessel for Sanmen 2 under the supervision of Westinghouse.[67]

A similar arrangement occurred with the purchase of the two Taishan EPR reactors from France, when China purchased the pressure vessel from Mitsubishi Heavy Industries (MHI) in Japan and the steam generators from Areva Chalon / St. Marcel in France for unit 1.

Doosan also has an agreement with China to supply heavy forgings and equipment for other projects in China, apparently in the 1,000 megawatts-electric (MWe) category. Doosan has supplied the steam generators for both Qinshan Phase III units (Qinshan 4 and 5), and the reactor vessels for both Qinshan Phase II units (Qinshan 2 and 3), as well as equipment for the two AP1000 units at Sanmen and two at Haiyang.[68] In 2008, Doosan Heavy Industries signed a memorandum of understanding (MOU) with China National Nuclear Company to bid jointly on nuclear power projects in southwest Asia and Africa.[69]

South Korea hopes that the contract with Westinghouse will be a stepping stone for its companies to expand in the nuclear power market in China and other countries. However, China wants to progressively become self-sufficient in deploying AP1000s and its own derivatives.[70] China is placing emphasis on using domestic products in the key equipment and components of nuclear reactors.[71] Whether and to what extent Doosan or other South Korean companies will be able to participate in future Chinese nuclear projects may depend on whether China has the domestic capacity to meet its ambitious nuclear power goals and to what extent it may have to resort to foreign companies to fill the gaps.

Continuation of South Korean cooperation with Westinghouse in the Chinese nuclear program could depend heavily on the peaceful nuclear cooperation agreement that the U.S. has in effect with China. This nuclear pact is set to expire in 2015, but the two countries are expected to conclude negotiations on a replacement agreement soon. Without a new U.S.-China agreement, it will be impossible for U.S. companies to export nuclear equipment, and very difficult to transfer nuclear technology, to China. Thus, to the extent that exports to China by Doosan and other South Korean companies are tied to Westinghouse's exports to China, it will be essential that Washington and Beijing renew their peaceful nuclear cooperation agreement (For a discussion on renewing this pact, see chapter 6).

India. India already has a large nuclear program and is seeking to expand it by importing foreign technology. New Delhi has signed a succession of agreements with Russia's Atomstroyexport to build VVER reactors. A 1,000-MW reactor is operating

at the Russian-built Kudankulam power station in India's Tamil Nadu Province, with a second due to come on line in 2015. In December 2014, India and Russia signed a strategic vision document on nuclear power that said that both sides would strive to complete the construction and commissioning of "not less than 12 units" in the next two decades. India agreed to expeditiously identify a second site, in addition to Kudankulam, for the construction of the Russian-designed nuclear power units in India.[72]

New Delhi has also signed agreements with Washington and Paris. Beijing also recently entered the picture, when Chinese president Xi Jinping, during his September 2014 visit to New Delhi, agreed with Indian prime minister Narendra Modi to open talks on nuclear cooperation.[73] India also signed a nuclear cooperation agreement with Australia in September 2014, clearing the way for importing Australian uranium. It is also engaged in talks with the European Union to sign a civil nuclear cooperation agreement.[74]

On June 13, 2012, Westinghouse Electric Company LLC and Nuclear Power Company of India Limited signed an MOU agreeing to negotiate an Early Works Agreement (EWA) supporting future construction of AP1000 nuclear power plants at the Mithivirdi site in Gujarat.[75] GE-Hitachi also plans to build a nuclear reactor at Gujarat.[76]

South Korea has expressed interest in participating in this market, but it is behind its competitors. In August 2009, Nuclear Power of India Ltd and KEPCO announced that they would conduct a study into the "licensability and constructability" of KEPCO's AP1400 reactors in India,[77] and on July 25, 2011, India and South Korea signed a civilian nuclear cooperation agreement.[78] A team from South Korea's Ministry of Science visited India in late 2013 and early 2014 to promote the sale of a nuclear power plant. However, the Indian government appears to want to limit its cooperation with the ROK to research for the time being. First, it wants to complete the projects that have already been initiated, including the Jaitapur reactor being built with French assistance and the Kudankulam 3 and 4 reactors being built with Russian assistance. The construction of these plants—along with the Mithi Virdhi nuclear plant, to be built with the assistance of the U.S.—has been delayed because of either supplier-country concerns about India's nuclear liability law or scheduling problems.[79]

The South Koreans are now awaiting allotment of a site by the Indian government for building a nuclear reactor. In addition to the economic benefits that might ensue from establishing a nuclear relationship between India and South Korea, the two countries are also likely to find political and strategic advantages in a strong civil nuclear relationship. Some have argued that it could help "build a strategic hedge—supported by other regional players, such as the United States, Japan, and Vietnam—against the emergence of China and the possibility of a Sino-centric continent."[80]

However, the initiation of the ROK's peaceful nuclear trade with India faces several obstacles, particularly if it involves the retransfer of U.S. nuclear technology from the ROK to India. First, many potential nuclear suppliers, including the United States and South Korea, will not export to India because New Delhi's 2010 law on civil liability for nuclear damage provides that operators of nuclear plants can hold foreign suppliers liable in the event of an incident due to faulty equipment or material supplied. This law conflicts with international conventions on liability and supplementary compensation, which channel responsibility for nuclear liability and compensation to the nuclear operator. Until this issue is resolved, India's hopes for importing nuclear technology from some suppliers will be delayed. However, Russia and India have recently reached an agreement related to their ongoing construction of units 3 and 4 at the Kudankulam nuclear plant. The terms resolved a disagreement over the implementation of the Indian civil liability law,[81] reportedly because Russia agreed to bear the cost of any compensation.[82] France has also indicated that it would decide on the best way

to work within the framework of the Indian liability law to provide nuclear reactors to India.[83]

The U.S. has a peaceful nuclear cooperation in effect with India, but actual cooperation has been delayed for several reasons. The first and most publicized of these is India's nuclear liability law. The two countries are endeavoring to resolve this issue, and during Prime Minister Modi's visit to Washington in September 2014, he and President Obama agreed to establish an interagency contact group to resolve all the outstanding issues hindering the rapid deployment of U.S.-origin nuclear reactors in India, including the liability issue.[84] Modi has reportedly asked his officials for an urgent solution to the liability problem. India has reportedly offered to establish an insurance pool to indemnify foreign nuclear suppliers against liability in the case of a nuclear accident in order to resolve this issue.[85]

For some countries, a second obstacle to opening nuclear trade with New Delhi has been India's inability to conclude a nuclear cooperation agreement with Japan. Japan has expressed interest in concluding a nuclear pact with India, but it has insisted on India's acceptance of nonproliferation commitments that India has thus far rejected. The absence of an Indian-Japanese nuclear pact could block the supply of U.S. reactor vendors—Westinghouse-Toshiba and GE-Hitachi—along with a range of other global nuclear reactor manufacturers, because the reactor pressure vessel for many reactors is made by Japan Steel Works. Without an agreement, Japan will not permit nuclear exports to India.[86]

A third obstacle to U.S. nuclear exports to India is New Delhi's reported refusal to provide the U.S. with information that tracks and accounts for material subject to the U.S.-Indian agreement.[87] The provision of such information is common practice among the major suppliers, but India has reportedly taken the same negative position with Australia and Canada. Without such reporting, the U.S. cannot know whether India is meeting its obligations to account for all the material that is subject to the agreement or to apply U.S. nonproliferation conditions to this material, including consent to reprocessing.

Moreover, section 104 of the Henry J. Hyde Act, which amended the Atomic Energy Act to permit U.S.-Indian nuclear cooperation, calls for a nuclear accountability program in implementing the U.S.-India nuclear cooperation agreement. It specifically states:

> *(A) IN GENERAL The President shall ensure all appropriate measures are taken to maintain accountability with respect to nuclear materials, equipment, and technology sold, leased, exported or re-exported to India so as to ensure*
>
> *i) Full implementation of the protections required under section 123 (a) (1) of the Atomic Energy Act of 1954 . . . and*
>
> *ii) United States compliance with article I of the NPT.*
>
> *(B) MEASURES— The measures taken pursuant to subparagraph (A) shall include the following:*
>
> *i) Obtaining and implementing assurances and conditions pursuant to the export licensing authorities of the Nuclear Regulatory Commission and the Department of Commerce and the Department of Energy, including as appropriate, conditions regarding end-use monitoring.*

Finally, article 17 of the U.S.-Indian agreement calls for an administrative arrangement which will provide that the principles of fungibility and equivalence must apply to the nuclear material subject to the agreement. This refers to the need for tracking and accounting of U.S. material subject to the agreement. The U.S. and India have not completed the administrative arrangements for operationalizing these aspects of the agreement.[88] The U.S. and India have not completed the administrative arrangements for operationalizing these aspects of the agreement.[89]

Until all these issues are resolved, U.S. nuclear exports to India as well as South Korean nuclear trade with India that is tied to U.S. export controls will be problematic.

Vietnam. Vietnam plans to build 10 nuclear reactors by 2030 for a total capacity of 10.7 GWe, accounting for 10.1 percent of electricity production. Vietnam selected Russia to build its first two nuclear power plants, with the commissioning of unit 1 commencing in 2023 and the second unit following a year later. The reactors are to be built from 2017 to 2023 as turnkey projects. Russia's Ministry of Finance is prepared to finance at least 85 percent of this first project, supply the nuclear fuel, and take back the used fuel for the life of the plant. The schedule for the country's second nuclear power project—to be supplied by Japan—at the Vinh Hai site (also in Ninh Thuan Province), will be delayed because of safety concerns following the March 2011 disastrous accident at Japan's Fukushima Daiichi plant.[90] The Japanese International Nuclear Energy Development Company (JINED) will work with Electricity Vietnam on the project, which will also involve financing and insurance of up to 85 percent of the total cost. JINED is a consortium of Japan's METI, nine utilities (led by Chubu, Kansai, and Tepco), and three manufacturers (Mitsubishi Heavy Industries, Toshiba, and Hitachi). [91]

South Korea seems best positioned for the supply of the third nuclear project, consisting of two 1,000 MW reactors. The two reactor projects are worth about $10 billion. South Korea and Vietnam launched a preliminary feasibility study in June 2013 on candidate sites and the safety of the third nuclear project.[92] When the project is approved by the Vietnamese National Assembly, South Korea is reportedly likely to receive the order for the project.[93]

The U.S. has recently concluded an agreement for peaceful nuclear cooperation with Vietnam that could facilitate American–South Korean nuclear collaboration with that country and, in particular, the retransfer of U.S.-origin technology from South Korea to Vietnam. In October 2014, a U.S. nuclear firm, Lightbridge Corporation, signed an agreement with the Vietnam Atomic Energy Institute for consulting services related to the construction and safe operation of Vietnam's Atomic Energy Research Center, including a nuclear research reactor.[94]

Indonesia. According to the World Nuclear Association, South Korea, Russia, and Japan, have expressed interest in helping Indonesia develop a nuclear power program. In July 2007, KEPCO and Korea Hydro & Nuclear Power Co. (KHNP) signed an MOU with Indonesia's PT Medco Energi Internasional to undertake a feasibility study on building two 1000 MWe OPR-1000 units from KHNP at a cost of $3 billion. This was part of a wider energy collaboration. In addition, the National Atomic Energy Agency (BATAN) has undertaken a feasibility study for a small Korean SMART reactor for power and desalination on Madura Island. However, this awaits the building of a reference plant in South Korea.[95]

Russia wants to export floating nuclear power plants on a fully serviced basis to Indonesia as a means of providing power to its smaller inhabited islands. The Province of Gorontalo on Sulawesi was reported to be considering a floating nuclear power plant from Russia.[96]

The Japanese and Indonesian governments signed a cooperation agreement in November 2007 for the preparation, planning, and promotion of Indonesia's nuclear power development and assistance for public relations activities. In August 2014, the Japan Atomic Energy Agency announced that it has agreed to extend this cooperation agreement with BATAN to include R&D on high-temperature, gas-cooled reactors.

Indonesia initially planned to build a nuclear power plant in 1997 but abandoned the idea the same year due to economic and political crises that occurred in the country. Indonesia is considering building

nuclear power plants with an initial capacity of 5,000 MW by 2025 despite strong domestic opposition to nuclear power. A senior official of Indonesia's Energy and Mineral Resources Ministry said that the government is still considering the technology used to build the nuclear power plant, with technology offered by Russia expected to take the first place. A visiting Russian delegation offered cooperation in building a nuclear power plant in Indonesia during its meeting with Indonesian vice president Jusuf Kalla in November 2014.[97] Russian Federation senior trade expert representative Sergey Kukushkin said that Rosatom was ready to not only transfer its nuclear knowledge and technology to Indonesia but also to finance the project.[98] Indonesian officials have also recently expressed interest in building small reactors (10–20 MW) in the Serpong area.[99]

The United States has an agreement for cooperation in effect with Indonesia that would enable and facilitate retransfers of U.S.-origin technology or components to that country if South Korea were to build a nuclear reactor there. However, it appears that Russia is in the lead for the provision of Indonesia's first reactor, if that country proceeds with a nuclear power program.

The Philippines. The Philippines built the Bataan Nuclear Power Plant in the early 1980s, but it never went into operation because it sits on a tectonic fault and volcano. The Fukushima disaster gave pause to efforts to revive the plant. South Korea is expected to agree to conduct a feasibility study into reviving the Bataan nuclear power plant project.[100] But prospects for nuclear power in the Philippines remain highly problematic. The U.S. has no peaceful nuclear cooperation agreement with the Philippines.

Malaysia. Although Malaysia has established a nuclear agency and has periodically reviewed plans for a nuclear plant, these efforts are at the feasibility stage. A nuclear plan was floated in December 2010 "to correct an imbalance" in energy sources. However, the government has quietly put a proposal to build two 1,000 MW nuclear power plants on the back burner. Nuclear energy is a highly sensitive issue in Malaysia and, according to government sources, "it may be revisited some time down the line."[101] The U.S. has no peaceful nuclear cooperation agreement with Malaysia, and the Malaysians do not appear ready to conclude one at this time.

Potential Markets in Europe

Romania. The South Korean government has indicated its interest in entering the Romanian nuclear energy market. The European markets have traditionally been dominated by French companies,[102] but China recently entered the picture when the China General Nuclear Power Corporation (CGN) submitted, on September 23, 2014 a binding offer to build two nuclear reactors for the town of Cernavoda.[103] China now appears to be a leading contender for the Romanian nuclear market. Economy Minister Constantin Nita said in an interview that "we will build the reactors with the help of Chinese investors. It's going to be a transparent procedure so that other investors would be able to participate too, but we have waited for 10 years for them to come and they haven't." [104] Romania turned to Chinese investors after companies such as ArcelorMittal and Enel SpA withdrew from a joint project set up to build the reactors to focus on other plans. According to Nita, once an accord is reached, CGN will hold the majority stake in the project, which the ministry estimates is worth about €6.5 billion ($8.8 billion), and will secure the funding. Nuclearelectrica SA, Romania's state-owned nuclear power generator, will keep a minority stake, which has yet to be determined.[105]

On October 19, Romania and CGN signed a joint letter of intent to build two new reactors in Romania's Cernavoda nuclear plant, for which the Chinese company has been designated an investor. According to Romania's state-owned nuclear utility, Nuclearelectrica, CGN was the only company that submitted qualifying documents.[106] China's

willingness to invest in the project appears to have been a deciding factor in Romania's favoring the Chinese over other competitors.

The U.S. has an agreement with Euratom that could facilitate U.S.-ROK nuclear cooperation with Romania, because that country is a member of the European Union. However, China appears to have locked up this market for the time being, and South Korea seems to be facing an uphill battle in penetrating the Romanian market.

Poland. Poland plans to construct at least two plants to provide 15 percent of its electricity needs. KEPCO intends to bid for these Polish units, but it seems to be behind other suppliers at the present time. In November 2009, France and Poland signed a joint declaration on energy and climate that, among other things, calls for France to assist Poland in the construction of nuclear power plants. The state-owned Polska Grupa Energetyczna SA then signed an agreement to work with Électricité de France to investigate using the European Pressurized Water Reactor technology for Poland, and Areva has said that it would bid in conjunction with Électricité de France. Poland signed a similar nonexclusive agreement with GE Hitachi early in 2010 regarding *advanced boiling-water reactor* (ABWR) and *economic simplified boiling-water reactor* (ESBWR) technology. Westinghouse has signed an agreement for its AP1000. Russian technology does not appear to be under consideration. The Polish National Atomic Energy Agency has signed cooperation agreements with the NRC and the French Autorité de Sureté Nucléaire, and it expects to also do so with the new South Korean Nuclear Safety and Security Commission.[107] The United States has an agreement with Euratom that could facilitate South Korean participation with U.S. nuclear firms in the Polish market.

The Czech Republic. The Czech government is considering opening a new selection process for building nuclear power units after the majority state-owned utility CEZ canceled a tender to build two new reactors of 1,200 MW each in April. KEPCO has shown interest in making a new tender. Areva and a consortium including Russia's Atomstroyexport and Westinghouse are also interested.[108] Westinghouse has reportedly offered to cofinance the construction of new nuclear plants in the Czech Republic.[109] China is also making a high-level effort to promote its nuclear technology to Prague. Chinese premier Li Keqiang met with Czech president Milos Zeman during his visit to Beijing October 27, promoting China's technology, pricing, and experience in building nuclear power plants.[110] The Czech government has indicated that the investor might be asked to take equity in the project.[111]

The Netherlands. On November 3, 2014, Delft University of Technology signed a $24 million contract with a South Korean consortium consisting of the Korean Atomic Energy Research Institute (KAERI), Hyundai Engineering, and Hyundai Engineering & Construction to upgrade the Reactor Institute Delft's 2 MW (thermal) pool-type research reactor. KAERI signed an MOU with TU Delft for further cooperation in research on radiation safety, the development of nuclear reactor technology, experimental nuclear reactors, radioactive waste management, radiation technology, nuclear medicine, and isotopes.[112] These steps illustrate South Korea's interest in the European market. However, the Netherlands has only one power reactor, and has made no decision on further builds.

The Middle East

Jordan. KEPCO and Doosan were reported to have offered Jordan the OPR1000 nuclear reactor. However, the OPR is not designed to meet Jordan's seismic requirements and would need to be upgraded. Jordan then considered the APR1400, but did not proceed with it. In August 2014, the Jordanian government confirmed that it had concluded an agreement with Russia's Rosatom to build the nation's first nuclear plants and had also designated a site for construction. Rosatom beat out Areva/MHI and Canada's CANDU to build two 1,000

MW pressurized water reactors. Russia will provide 49.9 percent of the project capital, with the remainder raised from public and private sources in Jordan. Rosatom will also own and operate the reactors, and the parties will work toward an agreement over power pricing, hoping to break ground on the $10 billion plant by 2015. That construction will take place near Qusayr Amra, northeast of Amman.[113]

South Korea will have a role in this project. On October 30, 2014, KEPCO Engineering & Construction Company signed a contract with the Jordan Atomic Energy Commission to assess the suitability of the candidate site for Jordan's first nuclear power plant at Al Amra. The contract is valued at around $15.3 million. It follows a competitive tender, concluded in April that involved bids from companies in seven countries, including the U.S., U.K., and Canada. Over the next 24 months, KEPCO will assess the site's suitability, examining detailed site plans, conducting environmental impact assessments, and providing licensing support for site approval.[114]

Although Russia has won the initial contract to build Jordan's power plants, South Korea and the United States may also have an opportunity to participate in the Jordanian nuclear program. On November 6, 2013, Khaled Toukan, head of the Jordan Atomic Energy Commission, said that after the Russian-built reactor is ready, Jordan plans to build several nuclear reactors with small capacities for power generation: "We plan to build several small nuclear reactors. Each of the small reactors will have two power plants with each having a capacity of 180 megawatts."[115]

South Korea has a $130 million agreement to build Jordan's first research reactor by 2015—the Jordanian Research and Training Reactor—a 5 MW reactor to run on 19 percent enriched fuel.[116] In February 2014, Jordan signed a $1.9 million contract with Advanced Systems Technology and Management, an American firm, to help oversee development of the research reactor. Advanced Systems Technology and Management has worked with Jordanian regulators since at least 2011 as part of the U.S. NRC'S International Regulatory Development Partnership, which helps countries establish licensing programs for power reactors. On January 22, 2014, Jordan and Saudi Arabia signed a nuclear-trade pact in Amman allowing cooperation on the development of peaceful atomic energy.[117]

Despite these steps to move forward with a nuclear program, Jordan faces a number of problems in realizing its nuclear ambitions. For one thing, it does not have the financial resources to fund a domestic nuclear power program. Amman also needs to establish a nuclear infrastructure and the necessary human resources as well as a legal and regulatory framework for the construction and operation of nuclear facilities. Moreover, there is strong opposition in Jordan's Parliament and among the public to acquiring nuclear power.[118]

Amman may have selected Russia to build its first nuclear power plant for financial reasons. Russia's state-owned nuclear company, Rosatom, is offering as a special package deal to "build, own, and operate" nuclear power stations abroad in a bid to win business from developing countries. The offer to build, own, and operate also includes financing for countries seeking to build nuclear plants. Rosatom won the bid to provide nuclear power plants to Turkey under similar financial terms.

The U.S. does not have a peaceful nuclear cooperation agreement in effect with Jordan. For a discussion of the status of negotiating a U.S. peaceful nuclear cooperation agreement, see chapter 6.

Saudi Arabia. On September 2, 2014, Saudi Arabia announced plans to construct more than a dozen nuclear power reactors over the next 20 years at a cost of more than $80 billion, with the first reactor coming on line in 2022.[119] Riyadh has been in discussions with a number of potential suppliers to achieve this goal. Saudi Arabia has signed nuclear cooperation agreements with several potential suppliers: with France in early

2011; with Argentina in 2011, apparently aimed at small plants for desalination; and with South Korea in 2011, calling for cooperation in nuclear R&D, including building nuclear power plants and research reactors, as well as training, safety, and waste management. In June 2013, KEPCO offered support for the localization of nuclear technology (i.e., employing local firms, along with joint R&D of nuclear technologies), if Saudi Arabia purchases South Korean reactors. Mohammed al-Jasser, Saudi Arabia's minister of economy and planning, told South Korean president Park Geun-hye that South Korea will be one of the countries to be invited to the Kingdom, if Saudi Arabia pursues a project to build nuclear reactors.[120] The Saudis also signed a 2012 agreement with China that relates to nuclear plant development and maintenance, research reactors, and the provision of fabricated nuclear fuel. In addition, the Saudis also indicated that they were negotiating with Russia, the Czech Republic, the U.K., and the U.S. regarding "further cooperation." The Saudis signed a nuclear cooperation pact with Japan in January 2011, under which Tokyo will provide Riyadh with a range of assistance, such as training Saudis in nuclear power generation technology, compiling the necessary laws, and other means.[121]

In September 2013, both GE Hitachi Nuclear Energy and Westinghouse signed contracts with Exelon Nuclear Partners, a division of Exelon Generation, to pursue reactor construction deals with the King Abdullah City for Nuclear and Renewable Energy. GE Hitachi is proposing its ABWR and ESBWR, while Westinghouse is proposing the AP1000 and its ABWR version. Areva is also interested in supplying its technology.[122]

China is also interested in the Saudi market, and the Chinese National Nuclear Energy Company (CNNC) signed an MOU with Saudi Arabia's King Abdullah City in August 2012.[123] The U.S. has been in discussions with the Saudi government about a civil nuclear cooperation agreement, but the talks have been stalled for some time. For an examination of the prospects for concluding such an agreement, see chapter 6. It bears emphasis, however, that despite signing these various international agreements, the Saudi government has not yet authorized the initiation of a nuclear energy program.

Egypt. In October 2006, the Egyptian minister for energy announced that a 1,000 MWe reactor would be built at El Daba'a by 2015. In December 2013, Egypt issued an international tender to build the Daba'a nuclear plant and to establish a bidding process for the rights to build the nuclear reactor at that site. Egypt plans to construct four nuclear power plants for the generation of electricity. The plants are planned to be operational between 2015 and 2025. Egypt has said that seven international companies have already applied to build Egypt's first nuclear power plant.[124]

In April 2013, the Egyptian government approached Russia to renew its nuclear cooperation agreement, which focused on the construction of a nuclear power plant at El Daba'a and the joint development of uranium deposits. In November 2013, the Russian foreign minister said that Russia was ready to finance an Egyptian nuclear plant.[125] Egypt announced on April 7, 2014, that Russia will provide Cairo with the fuel needed to operate the country's research reactor.[126] Egypt has agreed that the Russians will help in conducting studies at the Daba'a nuclear station and in developing the experimental reactor in Anshas. Work is expected to begin with the Russians on plans for building 4 GW (thermal) of nuclear power facilities by 2025.[127]

Russia appears to be the clear partner of choice to develop Cairo's first nuclear power plant. Russia's willingness to finance Egyptian reactors is clearly a key factor in that choice. South Korea is also interested in nuclear cooperation with Egypt, and on May 10, 2013, signed an MOU with Cairo that called for the two countries to cooperate to train the workforce for a nuclear power plant, share technical information, and discuss ways to appease the concerns of local residents.[128] In addition, in

November 2014, Korea Hydro & Nuclear Power, KEPCO Engineering & Construction Company, Daewoo Engineering &Construction, and Daelim Building participated in a "Korea Nuclear Industry Roadshow" in Cairo to promote exports of South Korean nuclear power reactors to Egypt.[129]

The Egyptian government is expected to give notice for an international bid for building a second nuclear plant at El Daba'a next year.[130] However, Egypt faces considerable political uncertainty in the aftermath of the overthrow of the Mubarak and Morsi governments. Its economy is in serious decline, and it is far too early to conclude that it will pursue a nuclear power program. The U.S. has a peaceful nuclear cooperation agreement with Egypt that will expire in 2021. It contains severe restrictions on reprocessing and plutonium use.

Turkey. Turkey wants to build a domestic nuclear industry over the next decade in order to reduce reliance on imported oil and gas. Turkey's first nuclear plant, at Akkuyu, under the ownership of Russia's Rosatom, aims to be operational in 2019. Rosatom invited Électricité de France, the French electric utility company, largely owned by the French government, to help build the power plant. A $22 billion contract has been awarded to a Japanese-French consortium to build Turkey's second nuclear power plant at Sinop on the Black Sea coast.[131]

In November 2014, Westinghouse, China's SNPTC, and the state-owned Electricity Generation Company (Elektrik Üretim A.Ş. Genel Müdürlüğü), the largest electric power company in Turkey, announced an agreement to enter into exclusive negotiations to develop and construct a four-unit nuclear power plant site in Turkey based on AP1000 reactor technology. The project also covers all life cycle activities, including operations, nuclear fuel, maintenance, engineering, plant services, and decommissioning.[132]

South Korea has also expressed interest in the Turkish market, and in a March 2010 agreement, KEPCO agreed to prepare a bid to build the plant at Sinop, with four APR1400 reactors starting operation from 2019. The bid included the local construction group Enka Insaat ve Sanayi. KEPCO was to take 40 percent equity in the plant, and would help with financing. However, this proposal foundered due to KEPCO's insistence on receiving electricity sales guarantees from the government, rather than from the Turkish Electricity Trade & Contract Corporation.[133]

The United States has a peaceful nuclear cooperation in effect with Turkey that would facilitate the retransfer of U.S.-origin technology to Turkey if Ankara decides to purchase Seoul's reactors.

Potential Markets in South Africa

According to the World Nuclear Association, the 2011 Draft Integrated Electricity Resource Plan for South Africa for 2010 to 2030 included six new 1,600 MWe reactors coming online in 18-month intervals from 2023. The South African electric utility Eskom has said that it would be looking for lower-cost options than the earlier AP1000 or EPR proposals it had received from Westinghouse and Areva, and would consider Generation II designs from China (perhaps CPR1000) or South Korea (perhaps OPR).[134] South Korea is interested in the South African market but faces aggressive competition from Russia, France, and China.

On September 22, 2014, Russia's state-owned Rosatom and the South African Department of Energy announced that they had reached an accord that laid the foundation for ordering as many as eight Russian VVER pressurized-water reactors. A joint statement issued by Rosatom and the South African Energy Department said that the agreement "lays the foundation for the large-scale nuclear power plants procurement and development programme of South Africa based on the construction in South Africa of new nuclear power plants with Russian VVER reactors with total installed capacity of up to 9.6GW (up to eight [reactor] units)"—which would be South Africa's

total planned nuclear capacity. This announcement prompted accusations that President Jacob Zuma's government had engaged in improper procurement practices. South Africa immediately announced that it had not yet awarded Russia a deal worth as much as $50 billion to develop eight nuclear reactors and that the two countries had merely signed a cooperation agreement. The president authorized the signature of an agreement with France, and said that South Africa planned accords with China and Japan.[135]

In October 2014, South Africa signed a nuclear cooperation agreement with France that will pave the way for establishing a nuclear procurement process. Areva is interested in developing nuclear projects in South Africa, notably through its Generation III+ EPR reactor technology.[136]

In March 2014, China's main nuclear power companies were reportedly seeking to bid for a contract to build six reactors by 2030. China's Ministry of Commerce reported that negotiations toward a nuclear cooperation agreement were proceeding. The energy minister said that this could involve the joint Chinese–South African marketing and supply of nuclear energy products, along with infrastructure funding to promote nuclear power developments across the region. In February, the Nuclear Energy Corporation of South Africa (Necsa) signed a skills development and training agreement with the two Chinese state-owned nuclear energy corporations, CGN and SNPTC, funded up to 95 percent by China.[137] On November 7, China and South Africa signed an intergovernmental agreement on nuclear cooperation.[138] This was followed in December 2014 with the signing of several nuclear accords, including an MOU on a nuclear fuel cycle partnership, a financing framework agreement for the construction of a new nuclear power plant in South Africa, and an agreement on nuclear personnel training. The MoU signed by Necsa and CNNC establishes a cooperative partnership between the two companies that will see CNNC support South Africa's nuclear industry. China's SNPTC, the Industrial & Commercial Bank of China, and South Africa's Standard Bank Group signed a power project financing framework agreement enabling cooperation on the financing of a nuclear power plant construction project in South Africa. The third agreement, also signed by SNPTC and Necsa, will see SNPTC provide training to South African nuclear personnel by providing training to about 300 South African nuclear professionals in a plan involving two years of basic training, professional training, and in-service training. This program will be officially launched in March 2015, according to SNPTC.[139]

In October 2013, Westinghouse signed an agreement with the Sebata Group of engineering companies to prepare for the "potential construction" of new nuclear plants. The U.S. has a peaceful nuclear cooperation agreement in effect with South Africa, but U.S. involvement in the South African nuclear program at this point appears to be limited to a March 2013 cooperation agreement with Necsa for the development of local facilities for fuel assembly components.[140]

South Africa held a second nuclear vendor workshop in late November 2014 (the first workshop was held in October in Moscow). The workshop involved presentations by vendors from China, France, the United States, and South Korea on how they propose to meet South Africa's nuclear power needs, including in areas such as conversion, enrichment, fuel fabrication, localization and industrialization, power generation, safety and licensing, job creation, R&D, skills transfer, and development. The workshop was designed to form part of the government's technical investigation in preparation for a procurement decision.[141]

Conclusion

Some of the countries that South Korea is targeting for its nuclear exports are in the early stages of planning nuclear power programs, whereas others are more advanced. Given the poor financial condition of some of these countries and their lack of

any kind of nuclear infrastructure, it is far from certain that the ambitious nuclear power programs of many of these countries will be realized.

Moreover, in pursuing its nuclear export goals, South Korea will face competition from the traditional suppliers, such as the United States, France, and Russia. Of these, France's Areva has suffered a major setback as a nuclear supplier as a result of the huge financial losses it has incurred in the much-delayed construction of the Olkiluoto 3 nuclear reactor in Finland, charges of disseminating misleading information, and continuing disputes with the Finnish utility TVO over compensation claims for costs and start-up dates before the arbitration court of the International Chamber of Commerce.[142] Areva, which narrowly escaped seeing its debt downgraded to junk status by Standard & Poor's rating agency in October 2014, is cutting investments and increasing sales of nonstrategic assets as it tries to shore up its finances.[143] One analyst recently noted that "it was clear that Areva had been struggling in the current environment," but that it now "looks more difficult than expected."[144]

However, though prospects for French nuclear exports may not be good, South Korea and the United States are confronting Russia's particularly aggressive nuclear export promotion policies. Moscow is winning competitions by offering below-market financing and providing a complete range of products and services, including manufactured parts, engineering services, construction, operations, maintenance, and fuel. It is also agreeing to take back spent fuel produced from the nuclear material it supplies. In countries with little or no domestic nuclear infrastructure or experience, including Turkey and Vietnam, Russia has offered a full build-own-operate model.

South Korea will also face competition from new nuclear suppliers such as China and Japan. Despite the Fukushima nuclear disaster, Japanese prime minister Shinzo Abe has been eager to promote Japanese nuclear exports. In addition to efforts to move forward with nuclear cooperation with India, Abe has been promoting Japanese technology in the Eastern European market. At a June 2013, summit in Warsaw of the so-called Visegrad Group—the Czech Republic, Hungary, Poland, and Slovakia—Abe sought to interest the four countries in purchasing Japanese nuclear technology. Promoting Japanese nuclear technologies is high on Abe's agenda for boosting overall Japanese exports.[145] MHI's European version of its advanced pressurized water reactor (EU-APWR) has recently been certified as compliant by the European Utility Requirements organization.[146]

Although China is facing strains in its capacity to meet its domestic construction goals, Beijing is also aiming to sell nuclear technology in the global market. According to the World Nuclear Association, China's policy is to "go global" by exporting nuclear technology, including heavy components in the supply chain. It says Beijing has a "determined" policy of exporting nuclear technology, based on China's development of the CAP1400 reactor, with Chinese intellectual property rights and backed by full fuel cycle capability. The policy is being pursued at a high level politically, and will make use of China's economic and diplomatic influence.[147] As noted above, China is pursuing aggressive financing tactics, as is evidenced by its willingness to invest in the reactors it is proposing to build in Romania. However, as Shanghai's *China Business News* reports, it will not be easy for China to market its nuclear power technology in the international market, because the country has not built a reactor that has adopted the reactor technology it is trying to sell abroad. The two Chinese companies involved in the development of this reactor technology—CNNC and CGN—have had several disagreements during their partnership and have been competing, instead of joining forces, to explore international opportunities.[148] However, the Chinese authorities are considering a plan to merge these two companies in order to increase China's competitiveness on the international stage.[149] In addition, as noted above, China has shown its willingness to team up with Westinghouse in making a joint bid to sell Westinghouse technology to Turkey.

CHAPTER 5

Potential Cooperation between the United States and South Korea in the Global Nuclear Market: Comparative Advantages and Disadvantages

The U.S. and the ROK already have extensive ties in the nuclear field, which include bilateral trade, cooperation in third-country markets, and collaboration in various R&D projects. The conclusion of a new U.S.-ROK peaceful nuclear cooperation agreement should enhance opportunities in all these phases of cooperation.

This chapter assesses the prospects for increased collaboration in the global market. It does not seek to identify specific projects or markets in third countries in which the South Korean and American nuclear companies could cooperate, because that is an issue that only the private firms themselves can decide, in light of their own commercial interests. Rather, its purpose is to identify the overall comparative advantages and disadvantages of the American and South Korean nuclear industries, recognizing that such relative strengths and weaknesses could in certain cases promote collaboration in some markets, while giving one country or the other an edge in competing for sales in other cases.

With this end in mind, the chapter begins with a description of the existing nuclear ties between the two countries and follows with an attempt to identify the strengths and weaknesses of the nuclear capabilities of the American and South Korean nuclear industries that might provide a basis for collaboration between the two countries.

Existing Cooperation

Bilateral nuclear cooperation between the U.S. and the ROK has been extensive and has involved (1) trade between the two countries, including American exports of nuclear materials, parts, and technology to South Korea as well as imports of South Korean nuclear equipment to support nuclear projects in the United States; (2) direct U.S. exports to third countries to support South Korean projects; (3) U.S.–South Korean joint ventures; and (4) participation in bilateral and international R&D projects.

U.S. exports to South Korea. The United States has played a vital role in the development of the South Korean nuclear industry. A total of 19 of South Korea's existing 23 reactors—along with those under construction, on order, or planned—are based on U.S. technology.[150] Since the start-up of South Korea's first commercial nuclear energy facility in 1978 (Kori-1), Westinghouse technology has formed the foundation of the South Korean nuclear energy program.[151]

As South Korea's nuclear program has grown and matured, the country's companies have come to play the major role in designing and constructing its nuclear power plants. The percentage of U.S. content in South Korean nuclear power projects has declined over the years, as South Korean content has increased. Nonetheless, there remains substantial U.S. content in South Korean plants,

and Westinghouse and other U.S. nuclear companies still supply the country with such items as instrumentation and control equipment, pumps, other major components, and technical and engineering services.[152]

Westinghouse is still working on five reactors under construction: Shin-Kori 2, 3, and 4; and Shin-Wolsong 1 and 2. The company is supplying components such as reactor coolant pumps and reactor vessel internals to the plants. U.S. suppliers have also provided South Korean reactors with nuclear fuel and fuel services. For example, since the inception of the South Korean civil nuclear program, a facility in Metropolis, Illinois, has provided uranium conversion services to KEPCO.[153] South Korea has also purchased enrichment services from the U.S., first from DOE and then from the United States Enrichment Corporation (USEC), when the private company took over the government enrichment facilities.

U.S. imports from South Korea. South Korean firms are significant suppliers to the eight Westinghouse AP1000 reactors under construction in the United States. For example, the two Westinghouse AP1000 reactors currently under construction in South Carolina will use reactor vessels and steam generators from Changwon, condensers from Sacheon, demineralizers and heat exchangers from Ansan, and valves from Cheonan.[154] Since 2006–2007, South Korean content in U.S. nuclear plants has become greater than U.S. content in South Korean plants.

Collaboration in third countries. In 2009, the UAE awarded a contract to construct four nuclear power reactors to a consortium led by KEPCO. The consortium includes Westinghouse Electric Company. The reactors that KEPCO is building in the UAE—APR1400s—use a Westinghouse-based design. As a result of the U.S. content in the APR1400 reactors and other U.S.-ROK supply relationships, American companies have a significant role in the UAE project. Westinghouse's contribution to the UAE reactors includes design, technical support services, consulting on licensing issues, and the provision of control equipment, instrumentation, and major components. In addition, a number of U.S. nuclear companies have provided engineering, construction management, training, legal, regulatory, environmental, and other services to the UAE project. U.S. exports to the UAE project are expected to exceed $1.5 billion.[155] The transfer of the APR 1400 technology from Korea to the UAE technology as well as other nuclear know-how was approved by the U.S. DOE, in accordance with the 10 *CFR* part 810 regulations described in chapter 2. Similarly, either the NRC or DOC approved the direct export of tangible items from the U.S. to the UAE project. All these approvals were facilitated by the U.S.-UAE agreement for cooperation.

Another important example of U.S.-ROK participation in third-country nuclear markets is the provision by South Korean companies of key equipment to Westinghouse reactors under construction in China. In April 2007, Westinghouse signed a letter of intent for a contract with South Korea's Doosan Heavy Industries for the supply of two pressure vessels and four steam generators for two AP1000 nuclear power reactors to be constructed in China—the Sanmen 1 and Haiyang 1.[156] The Sanmen 1 reactor pressure vessel arrived on site from Doosan in July 2011. As noted in the preceding chapter, the South Koreans hope that the contract will be a stepping stone for South Korean companies to expand in the nuclear power market in China and other countries. The pressure vessels for the other two units are being made by Chinese manufacturers.[157]

R&D cooperation. The U.S. and the ROK have a long history of R&D cooperation. The U.S. and South Korea built a 100-kilowatt research reactor, which began operating in 1962, and was later upgraded to 250 kilowatts and finally to 2 MW.[158]

The U.S. and South Korea also established the Joint Standing Committee on Nuclear Energy Cooperation in the early 1980s to provide a forum for exchanging views on nuclear R&D and other nuclear energy issues. In the 1990s, KAERI conducted a

joint research program with DOE national laboratories and Atomic Energy of Canada Limited on the DUPIC fuel cycle (direct use of PWR spent fuel in CANDU reactors, in which light water reactor spent fuel would be made into CANDU fuel without reprocessing). In 2002, the U.S. and the ROK undertook studies on pyroprocessing, in which U.S. and ROK scientists engaged in joint pyroprocessing experiments involving used nuclear fuel at U.S. laboratories. In 2011, the U.S. and South Korea agreed to a 10-year Joint Fuel Cycle Study (JFCS) on pyroprocessing, in which KAERI scientists would conduct spent fuel separation work at the Idaho National Laboratory and other U.S. facilities, while work in South Korea would be restricted to simulated material. The purpose of the JFCS is to explore the technical and economic feasibility and proliferation implications of the electrochemical recycling process and of other spent fuel management options. Argonne National Laboratory and KAERI signed an MOU on August 25, 2014, covering "a broad field of technical cooperation on nuclear science and technology." KAERI's Sodium-Cooled Fast Reactor Development Agency has provided $6.78 million funding to date for Argonne's contributions to the development of a Prototype Generation-IV Sodium-Cooled Fast Reactor.[159]

In addition to bilateral research projects, South Korea and the United States have worked together on several international R&D programs, including projects on advanced reactors under the Generation IV International Forum and the IAEA's International Project on Innovative Nuclear Reactors and Fuel Cycles, and the International Framework on Nuclear Energy Cooperation, focusing on the development of international reliable comprehensive fuel service arrangements and R&D priorities.

A new peaceful nuclear cooperation agreement between the United States and the ROK should offer opportunities for significant growth of the already extensive collaboration between the U.S. and the ROK in all three areas of bilateral trade, collaboration on joint projects in third countries, and joint R&D. The extent of this growth will depend on the relative strengths and weaknesses of the two countries' nuclear programs.

Comparative Advantages and Disadvantages of the U.S. Nuclear Industry

The U.S. nuclear industry enjoys a number of strengths in competing in the international market, including its long experience, advanced technology, and high safety standards. On the other hand, the American nuclear industry has lost much of its manufacturing capacity and has failed to build a new reactor in decades. It also does not benefit from the financial and political support that many of its competitors enjoy.

Strengths of the U.S. Industry

The United States has considerable experience and expertise in nuclear energy development that it can bring to bear in the international market. As the Nuclear Energy Institute (NEI) has recently pointed out, more than 60 percent of the world's 436 operating reactors are based on U.S. technology. Many of the 71 nuclear plants under construction around the world rely on U.S. companies for reactor designs, engineering, precision components, and high-performance nuclear fuel. NEI has summarized what it regards as the major advantages in deploying U.S. reactor technology and in employing U.S. companies to implement nuclear power development programs abroad. These include three major components: advanced reactor designs; services, fuel, and components; and excellence in nuclear safety:

> *Advanced reactor designs: U.S. companies are at the forefront of developing a fleet of world-class reactors, incorporating modular techniques for easier construction. New designs include large reactors such as the GE Hitachi ABWR, the only Generation III reactor in operation; the Westinghouse AP1000, a Generation III+ design now*

under construction in the United States and China; and the GE Hitachi ESBWR, another Generation III+ design. In addition, the U.S. Department of Energy is funding through public-private partnerships two U.S. companies to bring small, modular designs into operation by 2022.[160]

The U.S. is a leader in nuclear plant technology, with the two advanced reactors with passive safety systems—Westinghouse's AP1000 and GE's ESBWR. The industry hopes that these new plants—with their simplified design, greater fuel efficiency, and improved safety features, plus a new construction method and a new system of nuclear regulation—will result in faster and cheaper plants that will lead the way for a new generation of reactors and demonstrate the economic feasibility of nuclear power. However, the success of efforts to build new advanced nuclear power plants in the U.S. and to export this technology abroad will depend on the ability of the U. S. industry to demonstrate that it can build these new facilities within projected costs and on schedule.

Prospects for the United States' exports of its advanced nuclear reactor designs have received a recent boost with reports that China's main nuclear power companies are in various stages of negotiations to purchase eight third-generation Westinghouse AP1000 reactors, which, with the inclusion of machinery and services, are expected to cost $24 billion.[161] Export prospects were also given a boost by the announcement by Toshiba Corporation that it has reached agreements with GDF Suez of France and Iberdrola of Spain to take a 60 percent stake in NuGeneration Limited, the U.K.-based nuclear energy company that plans to develop nuclear power plants at the Moorside site in West Cumbria, northwest England. As the majority owner of NuGen, Toshiba, in collaboration with its group company Westinghouse, intends to begin the construction of three Westinghouse AP1000 nuclear reactors with a combined capacity of 3.4 GW at the U.K. site.[162] Westinghouse also entered into an exclusive agreement with Bulgaria Energy Holding in December 2013 for AP1000 technology, although it is unclear whether Bulgaria will have the financial resources to purchase a nuclear power plant.[163]

DOE conducts programs to develop advanced reactor technologies, including research, development, and deployment (RD&D) through its Next Generation Nuclear Plant (NGNP), Advanced Reactor Concepts, and Advanced Small Modular Reactor (aSMR) programs to promote safety, technical, economical, and environmental advancements of innovative Generation IV nuclear energy technologies. DOE pursues these advancements through RD&D activities at its national laboratories and U.S. universities, as well as through collaboration with industry and international partners. These activities focus on advancing scientific understanding of these technologies, establishing an international network of user facilities for civil nuclear RD&D, improving economic competitiveness, and reducing the technical and regulatory uncertainties of deploying new nuclear reactor technologies.

However, U.S. programs for Generation IV reactors are not as advanced as those in such countries as China, France, Russia, and South Korea. The U.S. does not have a very broad-based, integrated technology program aimed at developing any particular technology at this time.[164]

Small modular reactors. Both the American nuclear industry and the U.S. government have been placing increasing emphasis on developing and marketing so-called small modular reactors (SMRs)—less than 300 MW. The potential benefits of small reactors are lower unit capital costs compared with current reactors, factory fabrication, shorter construction times, lower financial risks, and the ability to add incremental capacity as it becomes needed, instead of having to find a gigawatt of demand at once.

DOE has pledged close to half a billion dollars in financing the development of SMRs and determining

whether they can be made cost-effective. DOE chose Babcock and Wilcox (B&W) in November 2012 and NuScale in December 2013 as recipients of a portion of the $452 million made available for SMR research for a six-year period starting in 2012. B&W and its partners—Bechtel International and the Tennessee Valley Authority (TVA)—had hoped to deploy B&W's 180-MW mPower by 2022.[165]

However, the development of SMRs faces significant challenges, including cost of development and challenges in obtaining NRC licensing.[166] NuScale, which hopes to build an SMR at the site of the Idaho National Laboratory, has warned that the design and design certification of an SMR take a long time and are very expensive (about $1 billion), and thus NuScale may need to seek new investors in its SMR program. In addition, B&W announced in November 2013 that it was facing a long-term financing problem and was accelerating its efforts to attract more investors. In April 2014, B&W announced that it was significantly restructuring its SMR program and that it may shut down a testing facility related to that program.[167] On the other hand, the TVA, which had hoped to partner with B&W, has announced that it plans to move ahead to develop an Oak Ridge site for a small nuclear reactor even if B&W decides not to proceed with the development of SMR technology.[168]

Although the commercial use of SMRs is about a decade away, the long-term objective of DOE and the nuclear industry is to help the U.S. capture the early lead in the race to commercialize SMRs in the international market. DOE believes that SMRs are ideal for small electrical markets and areas with limited water resources—that is, developing countries that may wish to launch new nuclear programs in the decades ahead.

The second major advantage of U.S. nuclear industry that NEI identified is:

> *Services, fuel, and components. With a U.S. fleet average capacity factor of approximately 90 percent, U.S. firms lead the world in operational expertise. U.S. companies excel in the full range of nuclear services, including engineering and construction, nuclear fuel services and more. Services for uranium conversion, enrichment and fabrication are available, and substantial new, advanced enrichment capacity is in various stages of technological development and deployment.*[169]

NEI has also pointed out that:

> *the U.S. nuclear industry has a proven record in working with partners around the world on technology transfer, localization, education and training, to enable broad and enduring industrial development. Many of the 71 nuclear plants under construction around the world rely on U.S. companies for reactor designs, engineering, precision components and high-performance nuclear fuel.*[170]

The U.S. has long been a supplier of uranium conversion, fuel fabrication, and uranium enrichment services. The Honeywell Metropolis Works plant in southern Illinois converts uranium oxide ore into uranium hexafluoride, a key raw material used to produce enriched uranium for use in nuclear power plants as fuel.[171]

The U.S. has five fuel fabrication facilities that convert enriched uranium oxide into solid pellets for fuel rods. Areva, Westinghouse, B&W, and General Electric operate fabrication facilities in Virginia, Washington State, North Carolina, and South Carolina.

U.S. nuclear exports include reactors, pumps, valves, piping, electrical wiring and components, engineering and construction services, supply of fuel and fuel services, operational support, training, and other services. In general, the U.S. industry has a cost advantage over European vendors, but its products are more expensive than those

of Asian countries. However, comparing relative costs is often difficult, particularly in cases where foreign companies are government-owned. In such cases, labor and productivity costs are not known because of a lack of transparency. For example, it is not clear whether Chinese nuclear plants are being built within budget because of the lack of transparency in Chinese labor and productivity costs. This is also true to a significant extent in South Korea, which has a completely different transparency system than the U.S. Russia also lacks transparency in its cost structure.

U.S. industry also has an advantage in the quality of its products and services. The U.S. does not make large pressure vessels but makes the products that are challenging to manufacture, such as high-precision components, rotating apparatuses like flywheels, reactor coolant pumps, and reactor vessels internals—all precision-engineered, highly machined parts. U.S. quality assurance standards and codes are the "gold standard" internationally. The U.S. also has a superior ability to troubleshoot problems when nuclear plants age and problems arise. U.S. industry is the first one to which operators look in order to fix problems.

U.S. nuclear industries operate plants economically and safely, and are known for the high quality of their management, and human performance. The U.S. also has a demonstrated ability to build plants internationally. For example, the second AP1000 plants being built in China at each site are well ahead of schedule.

For many years, the U.S. played a dominant role in the international enrichment market. This role has declined substantially with the entry of other enrichers, such as Urenco, Areva, and Russia. As of 2013, the U.S. had an enrichment capacity of 3.5 million separative work units (SWUs) per year, compared with a total world capacity of 51.5 million SWUs.[172]

The future of the U.S. enrichment industry is highly uncertain, largely due to the excess in global enrichment capacity, which has delayed the construction of new enrichment capacity in the U.S. and questions surrounding the future of the USEC—now known as Centrus Energy Corporation.[173] The U.S. currently has only one enrichment plant[174]—the Urenco USA centrifuge enrichment facility in Eunice, New Mexico. (In November 2012, it was reported that KEPCO was going to buy a stake in this Urenco plant.) In November 2012, Urenco applied for a license to increase its capacity from 3.7 to 10 million SWU per year, to allow for future commercial opportunities.[175]

USEC has closed its two large gaseous diffusion enrichment plants, but it continues to sell enriched uranium based on its 2011 contract with Tenex.[176] USEC had been counting on developing a new advanced centrifuge technology—the American Centrifuge Project (ACP)—to replace the outdated and costly gaseous diffusion technology and to keep it in the enrichment market in the future. However, USEC's efforts were set back by its failure to qualify for a DOE loan guarantee. Instead, DOE agreed to help USEC finance an RD&D program for the ACP technology. But the RD&D program has also run into considerable difficulties. DOE lost confidence in USEC's handling of the ACP, and in March 2014 announced that it would take over management of the project. In addition, on March 5, 2014, USEC filed for bankruptcy after it determined that it would be unable to repay its debt due later in the year. On September 30, 2014, USEC announced that it had emerged from bankruptcy and had changed its name to Centrus Energy Corporation. Centrus's fate will depend on continued financial support from Congress at a time of great fiscal austerity, on the ACP's technical success, on the commercial feasibility of the ACP technology, and on the future of the enrichment market.

Another enrichment facility under development in the United States is the GE-Hitachi Global Laser Enrichment (GLE) facility in Wilmington, Delaware. Some believe this laser technology will cut the cost of enrichment drastically. On January 20,

2014, GLE advised the NRC of GLE's intent to prepare a license application for the authority to construct and operate a laser enrichment plant, referred to as the Paducah Laser Enrichment Facility (PLEF). PLEF would be deployed as part of an agreement between GLE and DOE to purchase and reenrich DOE inventories of depleted UF6. The GLE technology clearly works, and appears able to offer more competitive prices than its centrifuge competitors. However, whether GLE will decide to fund the construction of a large, commercial facility in the face of today's excess global enrichment capacity remains to be seen. Thus it may require a few years before we know how the U.S. will compete in the global enrichment market.

The United States has also been a major supporter of international efforts to ensure that countries have access to a reliable nuclear fuel supply. As part of this effort, the U.S. has supported the IAEA's low-enriched uranium (LEU) bank and the Russian and U.K. fuel assurance mechanisms for IAEA member states. In addition, the United States has announced the availability of approximately 230 metric tons of LEU from the American Assured Fuel Supply (AAFS), which resulted from the down-blending of 17.4 metric tons of U.S. surplus HEU. The AAFS—the largest LEU fuel bank in the world—will serve as a backup fuel supply in the event of a fuel supply disruption.

In addition to U.S. nuclear fuel supply capabilities, the DOC has reported that the United States has top-performing companies all along the nuclear value chain—including 12 of the world's 25 highest-performing reactors; the only Generation II reactor in operation (GE Hitachi's ABWR reactor is only Generation III); 255 companies with so-called N-Stamps in mid-2008, up from 120 in the early 2000s;[177] and more than 20,000 U.S. small and medium-sized supply companies.[178]

The third major advantage of the U.S. nuclear industry identified by NEI is:

> *excellence in nuclear safety. Based on more than 50 years of experience, the U.S. nuclear industry continues to perform as one of the safest industrial working environments in the world. The U.S. supply chain leads the world in safety-conscious workforce training, operational excellence, and continuous improvement. Regulated by the NRC—the gold standard for nuclear regulators around the world—U.S. suppliers are known for process excellence, human performance and safety culture.*[179]

The diversity of the plant designs that U.S. industry deployed historically obliged the NRC to develop a substantially stronger and more independent system of scientific and technical assessment compared with the systems of other national nuclear regulatory agencies, which explains why the most important recent advances in commercial reactor technology have been made in the United States. In addition, the Three Mile Island accident prompted U.S. utilities to increase their cooperation by sharing detailed information about their operations, an effort that greatly improved the reliability of U.S. nuclear plants.[180] As a result, other nations not only look to the United States nuclear industry for operational expertise but also see the NRC as setting the international gold standard for safety and physical protection regulations.

Weaknesses of the U.S. Industry

On the other hand, the nuclear industry in the United States suffers from a number of significant weaknesses, including the failure to build a single domestic nuclear plant in 40 years, the atrophying of U.S. manufacturing capability, and inadequate financial and high-level political support from the U.S. government for its nuclear exports.

Failure to build. The United States has not built a single new nuclear facility in 40 years. The last year that a commercial nuclear reactor came online in the U.S. was in 1993—the Watts Barr plant in Tennessee, which began construction in 1973.

As a result of a number of factors—inexpensive natural gas, limited electricity demand, the costs of constructing new plants and the need to implement new NRC regulations in response to the Fukushima nuclear disaster, and the failure to find a permanent repository for high-level nuclear waste—the U.S. nuclear energy industry has been declining both domestically and internationally.

The Obama administration is trying to give a boost to nuclear power through a loan-guarantee program. DOE first offered loan guarantees for new nuclear power reactors in 2005, with Congress authorizing up to $17.5 billion. And in 2011, the administration asked that this amount be raised to $36 billion. However, demand for these loan guarantees failed to materialize. Only two new reactors under construction in Georgia obtained a loan guarantee. In February, DOE formalized $6.51 billion in federal loan guarantees to support the construction of two new nuclear reactors at the Alvin W. Vogtle Electric Generating Plant. The Scana nuclear plant under construction in South Carolina decided to forgo the DOE loan program and to rely on commercial financing. Thus, the loan guarantee program has had a limited effect on new construction to date.

In addition, for the longer term, on December10, 2014, DOE announced a solicitation of up to $12.6 billion in loan guarantees "to support construction of innovative nuclear energy and front-end nuclear projects in the United States that reduce, avoid, or sequester greenhouse gas emissions." Although any such project may apply, DOE said that the focus would be on four key areas: advanced nuclear reactors, SMRs, upgrades and uprates at existing reactors, and front end (fuel) projects.[181]

The building of new nuclear plants and the life extension of older ones also may critically depend on whether the U.S. government adopts a policy preference for the use of carbon-free, reliable fuel forms. On June 2, 2014, the U.S. Environmental Protection Agency (EPA) proposed emission guidelines—the Clean Power Plan—for states to follow in developing plans to address greenhouse gas emissions from existing fossil-fuel-fired electric generating units. Power plants account for roughly one-third of all domestic greenhouse gas emissions in the United States. The proposed EPA guidelines aim to cut carbon emission from the power sector by 2030 by 30 percent nationwide below 2005 levels, which is equal to the emissions from powering more than half the homes in the United States for one year. If properly drafted, the guidelines could favor the construction of new nuclear reactors. However, the nuclear industry has been highly critical of the guidelines, arguing that they would penalize nuclear generation.[182] The EPA has recently acknowledged that the nuclear provisions of the CPP "have raised concerns among stakeholders" and "would likely be revised."[183] Moreover, the implementation of the guidelines faces a number of obstacles, including likely legal challenges and congressional opposition.

Five nuclear plants are under construction in the United States—two AP1000 units at the Vogtle units 3and 4 in Georgia, two AP1000 reactors at the VC Summer Nuclear Station in South Carolina, and the TVA Watts Bar Unit 2. The TVA plant is expected to be completed in early 2015. However, all have faced significant delays and cost increases. Vogtle is the only nuclear power plant to receive a federal loan guarantee so far, and though there are additional applications to build nuclear power plants on file with the NRC, only a few new reactors are projected to be built. Investment in new reactors is taking place only in states in the Southeast, where the marketplace is more regulated and utility regulators guarantee the rate of return utilities receive for building and operating new plants. Outside the Southeast, most utilities do not operate in a regulated market. In these markets, the industry is experiencing a number of nuclear power plant closures. Five nuclear plants were retired last year, with three closings resulting from the fact that the plants could not compete with cheap natural gas prices and two occurring because of the plants' poor maintenance records.

Nevertheless, the fact that the United States has not built new domestic nuclear power plants in more than 30 years, combined with the uncertainty facing the industry's future, hurts U.S. prospects globally because countries seeking to develop nuclear power are likely to turn for assistance to those countries that have growing domestic nuclear power programs.[184]

Decline in manufacturing capability. The shutdown of old nuclear power plants and only limited new construction have led to a decline in America's nuclear manufacturing capability. The DOC has reported that the U.S. nuclear industry has atrophied and, according to U.S. government officials and nuclear industry representatives, may lack the capability to manufacture certain components and equipment needed to produce large civilian power reactors.[185] In the 1980s, for example, 100 percent of equipment for U.S. nuclear plants was manufactured in America, compared with less than 25 percent today.[186] All but one of the U.S. nuclear power plant vendors and nuclear fuel designers and manufacturers for light water reactors have now been acquired by their non-U.S.-based competitors.[187] A recent report concluded: "Unfortunately, the three-decade drought in the construction of new plants in the United States, corresponding with enormous growth in the nuclear energy infrastructure internationally, has led to this country becoming primarily a global service provider in nuclear energy."[188]

Inadequate financial and political support. The governments of other nuclear suppliers provide strong financial and political support, including direct government ownership or subsidies. In addition, although U.S. executive branch support for U.S. nuclear exports is excellent, foreign governments place greater emphasis on supporting bids through high-level diplomatic and political assistance. U.S. industry cannot expect the kind of high-profile support for its nuclear exports that has been given by the presidents of France, Russia, and South Korea to their nuclear exporters.

In addition, U.S. government financial policies to support U.S. nuclear exports are comparatively weak. The current policy of the Overseas Private Investment Corporation (OPIC), which is the U.S. government's development finance institution, currently prohibits nuclear power financing.[189] What little financial support the U.S. nuclear industry has received comes from the U.S. Export-Import Bank, whose support of nuclear exports, though far from robust, has not been insignificant.[190] Ex-Im does offer loans, whereas most of its foreign equivalents offer only loan guarantees. However, financial support for U.S. nuclear exports has long been controversial. More important, as noted in the previous chapter, Ex-Im's continued existence has been the subject of considerable controversy in Congress, and its charter has been extended only to June 30, 2015. As noted, the uncertainty of Ex-Im's future places the U.S. nuclear industry at a competitive disadvantage.

The U.S. nuclear industry regards Ex-Im as one of the most important tools available to promote U.S. nuclear energy exports to the large and growing global market. Marvin Fertel, president of the NEI, argued before the House Financial Services Committee on June 25, 2014, that the continuation of Ex-Im is essential to the global competitiveness of the U.S. nuclear industry. Among other things, he pointed out that Ex-Im has given the United States the leverage to impose discipline on the export credit agencies of other countries. Under the Nuclear Sector Understanding of the Organization for Economic Cooperation and Development (OECD), export credit financing terms and trade-related aid in the nuclear energy sector must conform to agreed-on limits. If the United States shuts down Ex-Im, it would lose its greatest source of leverage for disciplining the 59 export credit agencies operating worldwide. Fertel made particular note of the fact that China and Russia do not abide by the discipline of the OECD, and he took particular aim at Russia and its efforts to expand its influence through nuclear exports. He asserted that Russia has used aggressive financing terms, utilizing funds from the Russian treasury,

rather than an export credit agency, to increase its share of the global nuclear energy market. According to reports, Russia is providing 85 percent of the financing for the completion of two plants in Ukraine, and 85 percent of the financing for two plants in Vietnam. Hungary cited below-market interest rates for its recent award to Rosatom of a $13.5-billion tender for two new nuclear plants.[191]

The U.S. government's failure to supply adequate financial support may be particularly damaging to the prospects for U.S. nuclear exports in developing countries undertaking new nuclear programs. Caroline Reda, president and chief executive officer of GE Hitachi Nuclear Energy, recently wrote that "global opportunities in nuclear energy are concentrated mostly in emerging markets where financing is most critical and financial assistance, including the type Ex-Im provides, is often a prerequisite to bid. Many of our competitors are subsidized or wholly owned by governments that offer low-cost financing and other assistance through their Export Credit Agencies. These include competitors from France, the Republic of Korea, Russia, and others."[192]

Another factor that puts U.S. industry at a disadvantage is the growing trend among suppliers toward investment in plants they sell abroad. Most importing countries, especially developing economies, want co-investment as part of any deal to purchase foreign nuclear technology. Russia and France are best positioned for meeting such demands. In South Korea, KEPCO also appears ready to follow suit and invest in plants it sells abroad. The Japanese have an Ex-Im bank, but they also have an investment bank that could be employed for co-investment in reactors they sell on the global market.

The U.S. is at a distinct disadvantage when it comes to this kind of financing. GE's and Westinghouse's policies are evolving in support of building reactors in the U.K., where both are taking some investment positions in their projects. However, this approach has its limits because U.S. companies simply do not have the requisite finances to invest heavily in foreign reactor projects.

Another key factor that hurts U.S. exports is the fact that the U.S. nuclear industry, unlike most of its competitors, is independent from the government. Other nuclear suppliers offer their potential customers more assistance than the United States does in terms of financing, training, and educational exchanges. They also provide high-level political and diplomatic support to their nuclear industries. The secretary of commerce has established the Civil Nuclear Trade Advisory Committee (CINTAC) to advise him or her on the development and administration of programs to expand U.S. exports of civil nuclear goods and services. CINTAC supports DOC in its role as a member of the Civil Nuclear Trade Working Group of the Trade Promotion Coordinating Committee.[193] This group has recommended a number of steps that the U.S. government, industry, and others could take to advance the competitive position of U.S. nuclear exports.[194]

The GAO reported in 2010 that the Civil Nuclear Trade Initiative—established by DOC in October 2008 to help promote the competitiveness of the U.S. nuclear industry—had made limited progress and does not have a well-defined strategy to support and promote U.S. nuclear industry efforts to compete globally. Although some progress has been made since that report, the U.S. still remains far behind its competitors in providing a coordinated, sustained, and high-level governmental support for its nuclear export industry.[195]

As a consequence of these weaknesses in the U.S. nuclear position, the 2010 GAO report concluded that the United States' share of global exports of nuclear material, reactors, and components has declined in the past 15 years. Although the volume of U.S. exports of natural and enriched uranium has remained stable, the U.S. share of global exports for these materials has decreased significantly, from 29 percent to 10

percent during the period 1994–2008. The GAO also found that the United States imports nuclear material, nuclear reactors, major components and equipment, and minor reactor parts from other countries, concluding that the United States was a net importer of nuclear components and materials and suggesting a lack of comparative advantage in this industry.[196]

Comparative Advantages of the South Korean Nuclear Industry

The ROK civil nuclear program has emerged from its rather modest beginnings in the 1960s to rapidly acquiring the technology to design, build, and operate nuclear power reactors, and is poised to become a major player in the international market. Although public support for nuclear energy has declined as a result of the Fukushima nuclear disaster and a 2012 safety scandal over the supply of reactor parts with fake security certificates, South Korea still plans to add 11 more nuclear reactors by 2024. Twenty-three reactors currently supply a third of the country's power.[197] Until recently, South Korean nuclear expertise has been largely confined to building its domestic civil nuclear power and R&D programs. However, with the growing global interest in nuclear power, the ROK has begun to compete in the international nuclear export market. KEPCO's successful $20.4 billion bid to build four APR1400 reactors in UAE was a key step in establishing the status of the South Korean nuclear energy industry in the global nuclear energy market as the ROK beat out much more experienced nuclear exporters—France and a U.S.-Japan consortium.[198] A recent study identified several political, technical, and economic factors that contributed to the South Korean success in the UAE and that are indicative of the strengths of the South Korean nuclear industry in the international market:[199]

- The South Korean government gave high-level policy support to the Korean consortium, including leadership at the highest levels.
- South Korea has a close relationship with the United States and Westinghouse participated in the South Korean consortium.
- KEPCO has the highest "capacity factor"—the proportion of time that the reactor is generating electricity—and the lowest "unplanned shutdown" rate in the world.
- South Korean companies have proved themselves able to build nuclear power reactors in a relatively short time and follow a predictable schedule.
- The business model that KEPCO and its core group of subcontractors have used over the years is similar to the one that the UAE is planning to implement.
- South Korea committed to human resource development in the UAE in support of the development of a domestic nuclear energy workforce that is dominated by competent national talent.[200]
- South Korea presented a very favorable financial package, with its bid significantly lower than those of its competitors.

South Korea may be among the few countries that will have the industrial capacity to provide major nuclear systems.[201] Doosan Heavy Industries & Construction provides the main components for the nuclear steam supply system, such as steam generators, reactors (including internal structures), reactor coolant pumps, and instrumentation and control systems, among other components. Doosan signed a $200 million contract with Westinghouse in 2008 to supply the main plant components of the third-generation plant, the AP1000TM model, by 2014.[202] Doosan, in a consortium with KHNP and other South Korean and foreign firms, is now in a position to market a successor to the APR1400 in collaboration with Westinghouse.[203] Namjin Lee, general manager for Doosan Heavy Industries America Corp. has said that, with this experience, Doosan is now one of two suppliers in the world that can provide the

total solution—from heavy forging material to final assembly.[204]

Another South Korean strength is that its nuclear industry is well integrated. It is able to quote an accurate total price because key subcontractors are part of the team. Westinghouse does not have such an integrated team and has to assemble a group of subcontractors, and cannot be certain about a total project price. It is also not a construction company, and this is a disadvantage compared to South Korean companies.

The South Korean nuclear industry also has a number of other advantages: a good track record for construction, operation, and maintenance; consistent government policy; a strong nuclear infrastructure; on-time performance with good scheduling software; and robust supply chains—for engineering, construction, fuel, and competitive pricing with continuous production.

South Korea is also developing cutting-edge technology. For example, POSCO—a multinational steel-making company headquartered in South Korea—has developed an advanced corrosion-resistant stainless steel for use in the construction of nuclear reactors. This steel will help extend the life span of reactors, and the demand for this high-value-added product is increasing globally. The new steel product, branded SR-50A, will be used to build a nuclear reactor in the UAE by Hyundai Heavy Industries. This will give South Korea a strong position in producing a product that only a handful of steel makers in Europe and Japan manufacture.[205]

In order to promote its export goals, South Korea is investing significant financial and human resources in enhancing its own technological self-sufficiency, especially in the export of its APR1400 reactor. It is training more engineers—nearly 2,500 new nuclear experts annually—to support the requirements of exports as well as its domestic nuclear expansion plans.[206]

Government ownership of KEPCO presents a major competitive advantage for South Korean companies compared to the U.S. industry. Indeed, the highly coordinated support that the South Korean nuclear industry receives from the ROK government is an important factor bolstering the ROK's position in the global nuclear market. In 2011, the South Korean government announced that it was planning to launch a task force led by the Ministry of Strategy and Finance in collaboration with the Ministry of Knowledge Economy and financial institutions such as Financial Services Commission, Ex-Im Bank, and K-Sure (a state-run trade insurer), whose objective would be to spearhead South Korea's exports of nuclear power plants. The task force would be in charge of financing, strategic planning, and promoting cooperation among the involved institutions. This effort is seen as a significant factor for promoting plant exports to developing countries.[207]

South Korea is also building relationships with countries developing nuclear industries by establishing the Kori Nuclear Power Education Institute and KEPCO's International Nuclear Graduate School, where highly qualified students (half from outside South Korea) are trained in all aspects of the nuclear industry. South Korea is thus building an international framework of cooperation in education and development that should establish important contacts for its nuclear export industry in the future.[208]

South Korea is also looking to the future by developing several new reactor designs for its domestic market and for export. These include:

- *APR+*. This is a developed version of the APR1400, increased from a 1,400 MWe net output to 1,500 MWe and modified to improve efficiency and capacity factor over the APR1400s.
- *SMART* (System-integrated Modular Advanced Reactor). On July 4, 2012, the Nuclear Safety and Security Commission issued Standard Design Approval for the

KAERI-developed SMART small modular reactor—the first commercially licensed small modular reactor anywhere in the world. KAERI plans to build a test and demonstration unit by 2017. KEPCO Nuclear Fuel is providing design, support, and consulting services for nuclear fuel to be used for 45,000 kW SMRs being developed by the U.S. company NuScale Power.[209]

- *Sodium-Cooled Fast Reactor.* KAERI and the Sodium-Cooled Fast Reactor Development Agency (SFRA) are working on a project to construct a commercial fast reactor whose target "go/no-go" construction start date is 2019. According to SFRA, on-site spent fuel storage at Kori Unit 1 will be full in 2016. Recycling spent light water reactor fuel using fast reactors would, it says, improve the uranium utilization rate over 100 times, as well as reduce the volume of high-level, long-term waste that has to be stored.[210]

According to the World Nuclear Association, the main roles of South Korean nuclear R&D are to ensure that the national energy supply is secure, and to build the country's nuclear technology base so that it becomes a nuclear exporting country by early in the 21st century.[211]

Disadvantages of the South Korea Nuclear Industry

The South Korea nuclear program also suffers from some limitations and weaknesses that could adversely affect its competitiveness in the international nuclear market.

Inexperience. Notwithstanding its successful bidding for the UAE reactors, South Korea has limited involvement in the international nuclear market compared with its larger competitors. It may, therefore, be to its advantage to partner with foreign suppliers with more experience. As noted above, collaborating with Westinghouse in the UAE sale was an important factor in securing that bid.

Lack of a full-service package. Some South Koreans believe that the absence of domestic enrichment capability, in particular, will hamper the ROK's ability to export its reactors because some customers may be interested in a "full-service" package along with purchasing a nuclear power plant. However, South Korea's lack of an indigenous enrichment capacity may be easily addressed by teaming up with one of the many international enrichment suppliers, such as Urenco, Areva, and possibly the U.S.

Safety and reliability. One potential weakness of the South Korean nuclear industry results from some recent events that have damaged its reputation for reliability and safety, both domestically and internationally. The first was a series of steam generator tube and main condenser tube failures. In late 2011 Urchin Unit 4 (which was renamed Hanul Unit 4 in early 2013) suffered damage to 25 percent of its steam generator tubes. The plant was just over two years old, and the steam generators were designed for a life of more than 30 years. In 2012, KEPCO discovered that it had been supplied with nearly 8,000 parts for at least five reactors that had been falsely certified as genuine by eight unnamed suppliers. In May 2013, safety-related control cabling with falsified documentation was found to have been installed at four reactors. Investigations revealed the discovery of various unsavory practices by individuals and firms that resulted in the use of substandard parts, the filing of false quality assurance certificates, and various collusion/bribery schemes among varied personnel at contractors and in the KHNP universe of subsidiaries.[212]

The scandals led to the immediate shut down of several reactors and the postponement of the start-up or final construction of several others. In June 2014, a South Korean government audit revealed that a number of the country's nuclear firms have been using fraudulent certificates for their safety products. The audit by the Ministry of Trade, Industry, and Energy's internal auditor uncovered seven fake quality-assurance certificates for five

different types of components from four suppliers. The ministry revealed that the components with the fraudulent certificates play a direct role in nuclear energy plant safety.[213]

KHNP has taken steps to reshape its corporate culture and its allied and subsidiary concerns.[214] And South Korea's Nuclear Safety Commission has instituted a set of measures to enhance the safety of the country's reactors that will include heavier fines for safety-related crimes.[215]

It is not clear to what extent South Korea's recent safety scandals may damage its export prospects. South Korea's use of U.S.-based technology and the involvement of U.S. personnel in South Korea's domestic nuclear industry and exports may help enhance Seoul's nuclear competitiveness, given that other nations not only look to the United States industry for operational experience, but also see the NRC as setting the international gold standard for safety and physical security regulation.[216]

One additional step that South Korea could take is to move forward with KHNP's application for certification of its APR1400 reactor design for licensing in the United States. KHNP submitted the design certification application to the NRC in September 2013, following more than three years of preapplication discussions with the regulator. However, the NRC decided not to accept KHNP's application for certification of its APR1400 reactor design because it contained insufficient information in some areas.[217] The NRC told KHNP in December 2013 that the application's "deficiencies" were in the areas of instrumentation and control, human factors engineering, probabilistic risk assessment, and the environmental report. Once the deficiencies have been addressed, the NRC may complete reviewing it in 2017. The NRC's certification of the South Korean reactor could help to enhance South Korean nuclear exports' reputation for safety. KHNP was aiming to reapply for an APR1400 design certification at the end of 2014.[218]

Conclusion

Inevitably, American and South Korean industries will often be competitors in the global marketplace. The comparative strengths and weaknesses of the U.S. and South Korean nuclear industries may favor one or the other in direct competition for markets in third countries. For example, the strong political and financial support that the government of South Korea gives South Korean companies is an advantage versus American firms. South Korea's proven record of building reactors at low cost and on schedule, and its ability to provide major component parts that the U.S. no longer manufactures, puts the ROK in a strong position to compete not only with the United States but also with other suppliers. Conversely, the advanced reactor technology offered by the United States, the high American safety standards, and the strong political, economic, and strategic relationship the U.S. has with a number of countries could provide important advantages to U.S. firms. In some markets, each industry may see benefits in going at it alone as much as possible or teaming up with other partners, such as Westinghouse and China in Turkey.

In other cases, the two industries may complement each other and favor collaboration in joint projects in the global market. The U.S. and South Korean nuclear industries are natural partners in several areas, given the common technology, minimal language barrier, and the long-standing familiarity between the two industries, especially between KEPCO and Westinghouse. Both industries use the same codes and standards from the American Society of Mechanical Engineers, and the ROK has adopted NRC licensing practices and has introduced the Bechtel system of engineering. Project implementation is similar in both countries. Such commonalities should ease cooperation between the U.S. and ROK industries.

In addition, the relative strengths of one may compensate for the weaknesses of the other. For

example, the ROK is especially strong in its manufacturing capabilities of major components; the integrated nature of its industry; its good track record for construction, operation, and maintenance; the consistency of its government policy; its strong nuclear infrastructure; and the financial and political support it receives from the ROK government. These advantages may compensate for the sharp decline in some U.S. manufacturing capabilities.

The United States' strengths in safety may help compensate for the reputational damage that the ROK industry has recently taken in that area. American strengths in such areas as advanced reactor designs, safety, the provision of high precision products, and a proven record in constructing reactors in the global market could complement ROK capabilities. In addition, the political, economic, and strategic relationship that the two countries enjoy with each other may prove advantageous in winning contracts in some countries.[219]

One model for possible U.S.-ROK collaboration is the UAE project. That is, the ROK and U.S. would initially compete for a project, and then the winner could subsequently take on the loser as a subcontractor. In the UAE project, the Emiratis needed manpower, construction, and operation support. The ROK was able to meet those needs. Westinghouse could not provide the infrastructure for operations. KEPCO had much operation and maintenance experience and could provide its own experienced personnel. Westinghouse is providing design, technical support services, consulting on licensing issues and control equipment, instrumentation, and major components, as well as engineering, construction management, training, legal, regulatory, environmental and other services.[220] The model of the UAE deal is likely to be replicated in the next two reactors to be built in the UAE.

Another model would be the development of joint proposals by U.S. and South Korean companies, such as Westinghouse and KEPCO, in bidding for reactors in third countries. The U.S. and South Korea have not thus far collaborated on such a proposal. A joint proposal might make sense if one party decided that it did not want to compete for a particular project, or if it knew that there was little chance of winning the bid on its own. As described above, Westinghouse has adopted this model in its proposed collaboration with China's State Nuclear Power Technology Corporation in the development and construction of a four-unit plant for Turkey's state-owned Electricity Generation Co. Given Westinghouse's work with Chinese companies in constructing power reactors in China and China's ambition to become a major exporter, Westinghouse-Chinese cooperation on joint export projects could become more frequent—a development that could be in direct competition with South Korea's nuclear exports.

Nonetheless, there is a strong strategic rationale for close collaboration between the U.S. and South Korea. Both U.S. and South Korean nuclear industries will face fierce competition from Russia, which has many advantages in exporting its nuclear technology—its vertically integrated industry, strong support from government, political pressure, aggressive financing, and its spent fuel takeback policy. China is also likely to be a major force in the international market in the longer term.

As two countries with similar democratic values and economic systems—as well as the many commonalities in their nuclear energy programs discussed above—the U.S. and the ROK may find it advantageous to strengthen their civil nuclear collaboration to provide a counterbalance to Russian and Chinese influence in this key strategic area.

CHAPTER 6

The Potential Role of the U.S. Government in Promoting U.S.-ROK Collaboration

Most of the initiative for enhancing collaboration between the U.S. and the ROK in the global nuclear market will need to come from the private sector. As was already noted in the previous chapter, the extent of this collaboration would be based to a large extent on the comparative advantages and disadvantages of the two countries in the nuclear field. Thus, the U.S. government's role would necessarily be modest.

Nonetheless, the U.S. government can play a role in facilitating both South Korean nuclear exports to third countries and U.S.-ROK cooperation in the global market by (1) concluding bilateral U.S. peaceful nuclear cooperation agreements with potential new partners and renewing existing agreements; (2) facilitating approvals for the retransfer of U.S.-origin nuclear materials, equipment, and components from the ROK to third countries; (3) promoting U.S. nuclear exports by putting its own nuclear export house in order; and (4) expanding U.S.-ROK intergovernmental R&D cooperation. This chapter examines the prospects for, and obstacles to, taking these steps.

Peaceful Nuclear Cooperation Agreements

U.S. peaceful nuclear cooperation agreements will be necessary for direct U.S. nuclear exports of nuclear materials, reactors, and their major component parts to a third country as well as reexports of such items from South Korea in support of Korean participation in that country's nuclear program. Even in those cases where transfers or retransfers of U.S. nuclear items do not require a U.S. peaceful nuclear cooperation agreement, the U.S. would give considerable weight to whether it has such an agreement in effect with a third country when it considers individual requests to approve nuclear exports from the United States or retransfers by the ROK to that country.

The United States presently has 19 peaceful nuclear cooperation agreements in force with individual countries, as well as with Taiwan, with the IAEA, and with Euratom and its 28 member states. Most of the countries to which South Korea has shown interest in selling its nuclear products and services have agreements with the United States, the major exceptions being Jordan, Saudi Arabia, and the Philippines.

The United States' peaceful nuclear cooperation agreement with China will expire in December 2015, and its agreement with the ROK will expire in March 2016.[221] But the negotiations for both replacement agreements are nearing completion, and their texts are expected to be soon submitted to Congress.

The replacement of the existing U.S.-China peaceful nuclear cooperation agreement may well be controversial in Congress. Congressional review of the original agreement in 1985 proved especially contentious because of Chinese assistance to

the Pakistani nuclear weapons program. Congress enacted a resolution of approval that required the president to make a number of determinations regarding Chinese nonproliferation behavior and commitments before the pact would be allowed to enter into effect. The agreement finally entered into force in 1998, after China ceased its sensitive nuclear cooperation with Pakistan and Washington secured adequate nonproliferation assurances from Beijing.

During a recent Senate Foreign Relations Committee hearing on peaceful nuclear cooperation agreements, the committee chairman, Robert Menendez, made a pointed remark about China and its sale of reactors to Pakistan in violation of the NSG guidelines, and asked what price China should have to pay for this behavior.[222] He asked whether adherence to the NSG guidelines should be part of any new agreement with foreign nations. His calling out China on this issue suggests that some in Congress could raise objections to a replacement agreement with China due to its nuclear export policies. In addition, other controversial issues—such as China's human rights record, and its provocative actions in the South China Sea and East China Sea over disputed claims to islands there—are also likely to be raised by some in Congress. Conversely, the prospect that China will purchase eight new Westinghouse reactors valued at $24 billion will create strong commercial incentives for concluding a replacement agreement.[223]

Several countries in the Middle East have expressed an interest in initiating peaceful nuclear power programs. However, negotiating new peaceful nuclear cooperation agreements with countries such as Jordan and Saudi Arabia could present major challenges. First, these countries are in an especially volatile region characterized by domestic political turmoil; civil war; sectarian rivalries, both within and between countries, particularly between Sunni and Shia; the Israeli-Palestinian conflict; and resentment among Arab states over the undeclared nuclear weapons program of Israel and fears of the Sunni states about Iranian nuclear weapon ambitions. Some in the U.S. have expressed concerns that introducing nuclear power into this toxic mix would not be in the national security interests of the United States. At the very least, the U.S. government would regard it as vitally important that any new civil nuclear programs introduced into this region not include enrichment or reprocessing capabilities. It is highly doubtful that Congress would approve any agreement with a Middle Eastern state that did not contain some form of commitment to abstain from acquiring enrichment and reprocessing capabilities.

Moreover, two existing agreements with states in the Middle East already contain severe restrictions on the possession of enrichment and reprocessing. As described in chapter 2, the U.S.-Egypt agreement for peaceful nuclear cooperation provides that any reprocessing of U.S.-obligated nuclear material and any storage or fabrication of plutonium recovered must take place in facilities outside Egypt. In the agreed minute to the U.S.-Egypt agreement:

> *The Government of the United States confirms that fields of cooperation, terms and conditions accorded by the United States to the Arab Republic of Egypt for cooperation in the peaceful uses of nuclear energy shall be no less favorable in scope and effect than those which may be accorded by the United States to any other non–nuclear weapon state in the Middle East in a peaceful nuclear cooperation agreement. In this connection it is understood that the safeguards required by this agreement shall be no more restrictive than those which may be required in any peaceful nuclear cooperation agreement between the United States and any other state in the region.*

In this respect, the U.S.-UAE agreement goes even further, in that the UAE legally forswears the possession of both enrichment and reprocessing. In addition, in exceptional circumstances of nonproliferation concern, the United States may remove

special fissionable material subject to the agreement from the UAE. In the agreed minute to the U.S.-UAE agreement, the U.S. confirms that the fields of cooperation, terms, and conditions accorded by the U.S. to the UAE for cooperation in the peaceful uses of nuclear energy:

> *shall be no less favorable in scope and effect than those which may be accorded, from time to time, to any other nonnuclear weapon State in the Middle East in a peaceful nuclear cooperation agreement. If this is, at any time, not the case, at the request of the Government of the United Arab Emirates the Government of the United States will provide full details of the improved terms agreed to with another non–nuclear weapon State in the Middle East, to the extent consistent with its national legislation and regulations and any relevant agreements with such other non-nuclear weapon State, and, if requested by the Government of the United Arab Emirates, will consult with the Government of the United Arab Emirates regarding the possibility of amending this Agreement so that the position described above is restored.*

These "most-favored-nation" provisions create important incentives for the U.S. to include similar restrictions in any new peaceful nuclear cooperation agreements it reaches with other countries in the Middle East. Thus, it is highly probable that the U.S. will insist on incorporating a pledge not to acquire enrichment and reprocessing in new agreements with any states in the Middle East, including Jordan, Saudi Arabia, and the eventual replacement of its existing agreement with Egypt.

A possible Jordanian agreement. The U.S. and Jordan have been considering an agreement for peaceful nuclear cooperation for several years. The principal negotiating stumbling block has been the United States' insistence that Jordan agree to forswear enrichment and reprocessing. On several occasions, the head of the Jordanian Atomic Energy Commission, Khaled Toukan, has publicly rejected the U.S. request to abstain from acquiring enrichment and reprocessing capabilities because, in his view, that would amount to Jordan's renunciation of its rights to peaceful nuclear energy, as guaranteed by article IV of the NPT. The talks have been stymied over this disagreement.

From a practical point of view, Amman is not interested in reprocessing, but because it possesses considerable reserves of natural uranium, it does not want to foreclose the option of acquiring a capability to enrich that uranium. Nevertheless, Jordan's insistence on what it considers to be its right under the NPT to enrich uranium may be more a case of political posturing than one of practical significance. Jordan, like other Sunni countries in the Middle East, is concerned that Iran's development of its civil nuclear program is intended as a route to a nuclear weapons capability. In January 2014, Mohammad al-Momani, Jordan's minister of state for media affairs, said his nation would consider developing a "peaceful" nuclear energy program as a "strategic option."[224] This characterization of Jordan's intentions will only raise questions in Washington.

As noted in chapter 4, the Jordanian government has recently confirmed that it has concluded an agreement with Russia's Rosatom to build the nation's first nuclear plant under very favorable financial terms. Russia will build, own, and operate the reactors. In addition, the ROK has a contract to build a research reactor in Jordan that will be based on South Korea's 30-MW High-Flux Advanced Neutron Application Reactor.[225] If the ROK succeeds in winning a nuclear power reactor bid to Jordan, the conclusion of a U.S.-Jordanian agreement could facilitate South Korea's exports to Jordan. But whether the U.S. and Jordan will be able to conclude such an agreement remains to be seen because Amman has options to import its nuclear technology from other suppliers, and under particularly favorable financial conditions. Jordan, therefore, has little incentive to give a commitment to the United States to forgo enrichment and

reprocessing capabilities—unless its government makes a decision to conclude an agreement with the United States in view of its political ties with Washington and to burnish its nonproliferation credentials.

A possible Saudi Arabian agreement. Concluding a U.S.–Saudi Arabian peaceful nuclear cooperation agreement will face two potentially critical, interrelated political obstacles. The first concerns Riyadh's nuclear weapons intentions. The second is the United States' insistence on obtaining a strong Saudi commitment in any such agreement to forswear indigenous enrichment and reprocessing capabilities.

The Saudis have been outspoken in their fears of an Iranian nuclear weapon capability, and officials have warned that the Kingdom might acquire a nuclear weapons capability of its own if Iran goes down that route. In 2009, King Abdullah warned a visiting U.S. envoy that if Iran crossed the nuclear threshold, "we will get nuclear weapons."[226] Since then, officials of the Kingdom have sent the Americans numerous signals of their concerns about Iran's nuclear intentions. Most prominently, Prince Turki al-Faisal, who has served as the Saudi intelligence chief and as ambassador to the United States, warned in December 2011 that an Iranian quest for nuclear weapons and Israel's presumed nuclear arsenal might force Saudi Arabia to follow suit, stating that "it is our duty toward our nation and people to consider all possible options, including the possession of these weapons."[227]

In addition, at the Munich Security Conference in February 2014, Prince Turki al-Faisal suggested that if Tehran retained uranium enrichment capability in a final nuclear deal with the P5+1 countries (i.e., the permanent five members of the UN Security Council, plus Germany), then Riyadh and other Arab governments could pursue enrichment programs of their own. He stated: "I think we should insist on having equal rights for everybody; this is part of the [NPT] arrangement."[228] He reiterated this statement in late October.[229] More recently, he told attendees of a security conference in the Bahraini capital, Manama, that the Gulf states should be prepared for any possible outcome from Iran's nuclear talks with the world powers. He said: "We do not hold any hostility to Iran and do not wish any harm to it or to its people, who are Muslim neighbors. But preserving our regional security requires that we, as a Gulf grouping, work to create a real balance of forces with it, including in nuclear know-how, and to be ready for any possibility in relation to the Iranian nuclear file. Any violation of this balance will allow the Iranian leadership to exploit all holes to do harm to us."[230]

The Saudis have been concerned that the P5+1 talks with Iran will allow Tehran to maintain some limited uranium enrichment capability as part of a deal on Tehran's nuclear program. After these talks got under way, there was a spate of leaks that the Saudis may seek to obtain nuclear weapons from Pakistan. Some Western experts believe that Saudi Arabia has given generous financial assistance to Pakistan's defense sector over the years, including its missile and nuclear programs, with the understanding that Riyadh could obtain a nuclear weapons capability in return, if and when the Kingdom decides to acquire nuclear weapons to counter a nuclear Iran. In response to these reports, the Saudis have pointed out that the Kingdom is a party to the NPT and has worked for a nuclear-free Middle East. But they have also pointed out that the UN's "failure to make the Middle East a nuclear free zone is one of the reasons the Kingdom of Saudi Arabia rejected the offer of a seat on the UN Security Council."[231]

In May 2008, the U.S. and Saudi Arabia signed a "U.S.–Saudi Arabia Memorandum of Understanding on Nuclear Energy Cooperation," in which "Saudi Arabia has stated its intent to rely on international markets for nuclear fuel and to not pursue sensitive nuclear technologies, which stands in direct contrast to the actions of Iran."[232] However, there is little doubt that the U.S. will call for a legally binding pledge in any U.S.-Saudi peaceful nuclear cooperation agreement that Saudi Arabia

will not acquire such technologies. The Saudi civil nuclear establishment seems interested mostly in a secure supply of nuclear fuel, but sources familiar with U.S.-Saudi talks say that Riyadh has argued that Washington's insistence on a pledge by Riyadh to forgo enrichment and reprocessing capability represents an unacceptable infringement on its national sovereignty, emphasizing that the NPT gives its parties a right to develop peaceful nuclear energy.[233] Moreover, reports have surfaced that the Saudis have been pursuing scientific and engineering expertise for all aspects of the nuclear fuel cycle, including employing technical experts capable of constructing the centrifuge cascades required to enrich uranium.[234] Whether Washington and Riyadh can reach agreement on the enrichment and reprocessing issue remains to be seen. The Saudis are unlikely to accept a formal legal pledge to forswear these technologies, though they might be willing to go along with a statement of intent not to acquire enrichment and reprocessing as was the case for the U.S.-Vietnam agreement. But is it not certain any U.S. administration or Congress would be willing to accept this approach.

As described in chapter 4, Saudi Arabia has signed preliminary agreements with a number of countries—including China, France, and South Korea—to help the Kingdom compare available options for its long-term program to build alternative energy plants for electricity production and water desalination. Although the Saudis have made no decision to proceed with a nuclear program, they have options other than U.S. supply.

Needless to say, the Saudis' public statements about their interest in nuclear weapons and reports of Saudi actions to acquire enrichment expertise will make it difficult for the U.S. to conclude a peaceful nuclear cooperation agreement with the Kingdom. However, if the P5+1 are successful in concluding an agreement with Iran that places effective constraints on Tehran's ability to rapidly acquire a nuclear weapons capability and includes rigorous monitoring by the IAEA, then other countries in the region, including Saudi Arabia, will have a considerably weaker incentive to acquire their own enrichment and reprocessing capabilities.

The Egyptian agreement. As discussed in chapter 4, the existing U.S. agreement with Egypt, which expires in 2021, contains special restrictions on the reprocessing of the spent fuel that is subject to the agreement. However, it does not go as far as the UAE agreement in securing a commitment from Egypt to make a legal commitment to forswear the possession of both enrichment and reprocessing on Egyptian territory. If the U.S. decides to conclude a replacement agreement with Egypt, it will most likely demand the commitment found in the UAE agreement not to acquire enrichment and reprocessing capabilities.

The absence of a U.S. peaceful nuclear cooperation agreement with these countries could adversely affect South Korean–U.S. collaboration in these markets. Without such an agreement, the U.S. could not export nuclear materials, reactors, or their major components to these countries, nor could it permit the retransfer of such items from the ROK to these states. The absence of an agreement would also make it more difficult for the U.S. to approve nuclear exports or reexports to these countries of nuclear components that do not require an agreement, because the U.S. takes into account whether a country has an agreement in effect with the U.S. when licensing or approving the exporting or reexporting of such items. In addition, the exporting or retransferring of technology to a country without an agreement would not be generally authorized and would require specific authorization from the secretary of energy.

Thus, a U.S. peaceful nuclear cooperation agreement with these countries will either be necessary for South Korea's reexports of nuclear materials, facilities, and major equipment to these countries, or will facilitate U.S. approval of other nuclear components or technology from the ROK to these countries.

Facilitating Approvals for the Retransfer of U.S.-Origin Nuclear Materials, Equipment, and Components from the ROK to Third Countries

In addition to replacing expiring agreements for cooperation and negotiating new ones with countries that the ROK sees as potential customers for its nuclear exports, the U.S. can take steps to facilitate retransfers of U.S.-origin nuclear materials, equipment, components, and other substances to such countries. For example, the agreed minute to the United States–Euratom peaceful nuclear cooperation agreement provides that:

> *the Parties shall exchange lists of third countries to which retransfers may be made by the other Party. Eligibility for continued inclusion on such lists shall be based, as a minimum, upon satisfaction of the following criteria:*
>
> > *third countries must have made effective non-proliferation commitments, normally by being party to, and in full respect of their obligations under the Non-Proliferation Treaty or the Treaty of Tlatelolco and by being in compliance with the conditions of INFCIRC 254/REV 1/Part 1, and*
> >
> > *in case of retransfer of items obligated to the United States from the territory of the Member States of the Community, third countries must be party to a nuclear cooperation agreement with the United States.*

The agreed minute also allows for the addition of other countries to the list and specifies that, in considering such additions, the U.S. and Euratom shall take into account the following additional criteria:

- *consistency of the proposed action with the guidelines contained in IAEA document INF-CIRC (information circulair) 225/REV 3 and with the provisions of IAEA document INFCIRC 274/REV 1, as they may be revised and accepted by the Parties and the Member States;*
- *the nature and content of the peaceful nuclear programs of the third country in question;*
- *the potential proliferation and security implications of the transfer for either Party or a Member State of the Community.*

Retransfers to third countries not included on the lists may be considered on a case-by-case basis. The U.S. could enter into a similar arrangement with the ROK that would greatly facilitate retransfers to third countries of items that are subject to the U.S.-ROK agreement.

In addition, the U.S. could give its advance consent to South Korea to transfer its spent fuel to Euratom for reprocessing. The U.S. has done this in other agreements—for example, the UAE and Taiwan agreements—and such consent could assist the ROK in meeting its immediate needs to resolve its spent fuel storage problems.[235]

Facilitating Transfers and Retransfers of U.S. Technology from South Korea to Third Countries

The U.S. could help with facilitating retransfers of U.S.-origin technology from South Korea to third countries by reforming its regulatory process (10 *CFR* part 810) that governs approvals of transfers and retransfers of U.S.-origin technology. As noted in chapter 2, current DOE procedures allow for facilitated approvals of certain transactions involving nonsensitive technology or assistance to countries that share the United States' nonproliferation objectives. In such cases, transfers are "generally authorized" and do not require a special authorization from the secretary of energy. For transfers to other countries and transfers of sensitive nuclear technology, the part 810 regulations require a special approval by the secretary of energy. As discussed elsewhere, DOE is in the process of proposing

major changes to these regulations. One such change would add the UAE to the list of countries for which technology transfers are generally authorized. Other countries with which South Korea is cooperating or is planning to cooperate and that are not eligible for general authorization include Jordan, Saudi Arabia, China, and India. The U.S. could help facilitate South Korean retransfers of U.S.-origin technology by reforming its part 810 regulations to improve their clarity and by expediting the approval process.

Improving the United States' Export Performance

If the U.S. is going to become a more effective partner with South Korea in the global nuclear market, it will need to take steps to improve its own nuclear export performance. Various organizations have issued reports calling on the U.S. to take steps to strengthen the domestic U.S. nuclear energy sector and to help American industry play a leading role in the global market for nuclear energy.[236] These recommendations have called for:

- Increasing the usefulness of the Export-Import Bank of the United States in supporting U.S. nuclear exports;
- Simplifying the U.S. export regulations for commercial nuclear technology, including by clarifying authority and consolidating it in one agency and making the export license process streamlined and timely; and
- Continuing efforts by the NRC and industry to strengthen nuclear plants' safety and security, particularly in light of the lessons learned from the Fukushima nuclear disaster in order to maintain U.S. leadership in nuclear safety and security.

CINTAC, which is an advisory board to the U.S. secretary of commerce, makes recommendations on ways to promote U.S. nuclear exports. Among other things, CINTAC has recommended that the U.S. government take steps to:

- bring the Convention on Supplementary Compensation for Nuclear Damage into effect as the highest diplomatic priority;
- work with the U.S. Treasury to encourage international lending institutions (e.g., the World Bank, OPIC) to lift their prohibitions on supporting nuclear projects;
- reform the part 810 licensing rules to expedite trade and to bring certainty to processing and timeliness in issuing licenses;
- create a team of U.S. industry, government, academia, and research labs—a so-called Team USA approach—that would, among other things, support domestic and international commercial nuclear opportunities and work to level the international playing field by opening markets and encouraging consistent commercial practices worldwide;
- help maintain and grow the technically competent U.S. nuclear workforce necessary for continued competitiveness in a global nuclear market;
- develop a technology road map that includes strategies to increase the industry's familiarity with the resources offered by the national laboratories, encourages new technologies by leveraging national laboratory resources and capabilities, and develops cost sharing programs to mitigate front end costs of new technology;
- develop and expeditiously implement a plan to handle spent nuclear fuel. Without this step, U.S. companies will be hindered in the front-end deployment of reactors, fuel, and services both domestically and overseas, because buyers desire a complete nuclear solution, including the back end of the fuel cycle;
- accelerate and simplify the commercialization of advanced nuclear technologies from the national laboratories to U.S. companies by rebuilding the industry's relationship

with government-funded research programs and by establishing a decade-long Nuclear Technology Competitiveness Initiative;

- continue the U.S. government's strong support for international trade missions to facilitate the U.S. industry's entry into the global commercial nuclear market and to increase its leverage of geopolitical relationships to ensure open markets and consistent fair play in commercial nuclear tenders and bidding processes; and
- reallocate funding and resources devoted to promoting commercial nuclear export opportunities. This will increase the U.S. government's focus, improve the probability of success for important tenders, and provide substantial support for the President's National Export Initiative.[237] (President Obama announced this initiative in his 2010 State of the Union Address to renew and revitalize U.S. efforts to promote American exports.)

A senior State Department official has noted that the president is emphasizing the importance of nuclear power both domestically and internationally. As she explained, "We must harness the power of nuclear energy on behalf of our efforts to combat climate change and advance peace and opportunity for all people."[238] Internationally, the U.S. believes that its "nuclear exports are a key strategic asset—a mature energy technology that does not emit greenhouse gases, while also providing a source of base-load electric power. Nuclear energy has an important role to play in pursuing our foreign policy objectives. Our top priority, though, is to make sure that U.S. access to energy is secure, reliable, affordable, and sustainable."[239]

As noted above, the Obama administration has sought to promote nuclear power in the United States, among other things, through a loan guarantee program for new nuclear power reactors that may prove critical to a renaissance of the U.S. nuclear industry.

In addition, the Obama administration has also taken several organizational steps to improve U.S. competitiveness in the international nuclear market. As noted, it is developing a "Team USA" approach to civil nuclear engagement abroad. In January 2012, it created a new position—director of nuclear energy policy in the White House—to lead this effort. In addition, DOC's Advocacy Center, the State Department, and other U.S. government agencies are working to put the U.S. government's support behind American bidders for international sales. DOC has also established a Civil Nuclear Trade Initiative to identify the U.S. nuclear industry's trade policy challenges and commercial opportunities and to coordinate the public and private sectors' efforts to support the growth of the U.S. civil nuclear industry.[240]

Nevertheless, as indicated in the recommendations of various groups noted above, more needs to be done by the U.S. government to give American nuclear exports the same kind of support that other governments do to back their industries in the international nuclear market.

Expanding U.S.-ROK Intergovernmental Nuclear Research and Development Cooperation

As described in chapter 5, South Korea and the United States have enjoyed a long and cooperative bilateral relationship in nuclear R&D. Both countries also participate in a range of international R&D efforts.

However, there may be potential for broader cooperation between DOE and its laboratories on the one hand, and the ROK's corresponding institutions on the other hand. DOE conducts a number of programs to promote nuclear energy as a viable energy source and to support R&D activities aimed at resolving the technical, cost, safety, waste management, proliferation resistance, and security challenges of using nuclear energy. These include wide-ranging nuclear R&D programs to (1) develop technologies and other solutions that

can improve the reliability, sustain the safety, and extend the life of current reactors; (2) develop improvements in the affordability of new reactors to enable nuclear energy to help meet U.S. energy security and climate change goals; (3) develop sustainable nuclear fuel cycles; and (4) understand and minimize the risks of nuclear proliferation and terrorism.[241] DOE's major nuclear R&D programs include the following:

- *Reactor concepts research, development and demonstration.* This program is designed to develop new and advanced reactor designs and technologies that enable improved competitiveness and safety.
- *Next Generation Nuclear Plants.* The NGNP program is designed to investigate the technical viability of high-temperature, gas reactor technology to provide more efficient carbon-free electricity and high-temperature process heat for a variety of industrial uses. The program is focused on long-term R&D and includes materials and fuels testing, such as the irradiation testing of graphite materials. The program also involves collaboration with the NRC to develop a licensing framework.
- *Light Water Reactor Sustainability*. The Light Water Reactor Sustainability program, which is closely coordinated with the NRC and shares costs with the Electric Power Research Institute, explores extending the operating lifetime of current plants beyond 60 years and, where possible, enables further improvements to be made in their safety and productivity.
- *Waste management*. Following the cancellation of the Yucca Mountain Nuclear Waste Repository program, the Obama administration established the Blue Ribbon Commission on America's Nuclear Future to conduct comprehensive recommendations for creating a safe, long-term solution for managing and disposing of the nation's spent nuclear fuel and high-level radioactive waste. The commission issued its final report on January 26, 2012, and in January 2013, DOE released its "Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste," which lays out plans to implement a long-term program that begins operation of a pilot interim storage facility by 2021, advances toward the siting and licensing of a larger interim storage facility by 2025, and makes demonstrable progress on the siting and characterization of geologic repository sites. The strategy fully endorses the need for a consent-based process for siting facilities, whereby jurisdictions are treated as partners and consent is obtained at multiple levels to provide the stability, focus, and credibility needed to build public trust and confidence.[242]

The U.S. and the ROK are already examining prospects for the long-term storage of spent fuel. The two governments could continue and extend their cooperation in this area. In addition, the siting and characterization of geological repositories may be a particularly fruitful area for joint study and cooperation by the ROK and U.S. governments.

Possible broadened U.S.-ROK intergovernmental cooperation. Given the broad range of activities in which DOE and its national laboratories are engaged, South Korea might find it beneficial to expand and deepen its relationship with DOE vis-à-vis nuclear issues, and possibly also its relationships with other U.S. government agencies in a way that would parallel DOE's broader cooperative relationships with other countries. For example, DOE has Action Plans and MOUs with several major nuclear powers—preeminently, China, Japan, and Russia—that more efficiently facilitate R&D by enabling intergovernmental collaboration involving the key facilities and technologies unique to each country and government agency.

Cooperation with China. The U.S.–China Bilateral Civil Nuclear Energy Cooperative Action Plan involves joint studies of advanced nuclear technologies and includes six technical working groups

focusing on fast reactor technologies, advanced separations technologies, advanced fuels and materials development, nuclear safety enhancement, spent fuel storage and repository science, and high-temperature gas reactor technologies. An MOU between DOE and the Chinese Academy of Sciences for cooperation on nuclear energy sciences and technologies seeks to foster nuclear energy collaboration among U.S. and Chinese scientists, laboratories, research institutes, and universities in such areas as molten salt coolant systems, nuclear fuel resources (the extraction of uranium from seawater), and nuclear hybrid energy systems. The Peaceful Uses of Nuclear Technology Agreement with China focuses on nuclear safety.

Cooperation with Japan. The U.S.-Japan Bilateral Commission on Civil Nuclear Cooperation, which was established in 2012, serves as a standing senior-level forum to foster a comprehensive strategic dialogue and joint activities related to the safe and secure implementation of civil nuclear energy and the response to Fukushima nuclear disaster. In July 2012, the Bilateral Commission endorsed the creation of the new Civil Nuclear Energy R&D Working Group to enhance the coordination of U.S.-Japan joint civil nuclear R&D efforts, building upon collaborative R&D objectives that were created in 2007. This working group is now coordinating cooperative nuclear energy R&D in several of the topical areas previously supported under the United States–*Japan* Joint Nuclear Energy Action Plan, including advanced reactor and fuel cycle technologies and a number of new areas endorsed by the Bilateral Commission, such as existing reactor fleet sustainability. The commission has five working groups to coordinate bilateral cooperation. They cover the following subjects:

- nuclear security;
- civil nuclear energy R&D;
- safety and regulatory issues;
- emergency management; and
- decommissioning and environmental management.

Action plan with Russia. DOE also has an action plan with Russia that includes reactor demonstration projects; R&D for innovative nuclear energy technology options; modeling, simulation and safety; and development of a global civil nuclear framework.[243]

The ROK and the United States might find it useful to enhance and broaden their cooperation through the establishment of similar relationships with DOE. This strengthened R&D cooperation could lead to the development and commercialization of new technologies that could, in turn, strengthen both countries' competitiveness in the global market and enhance their prospects for collaboration in third countries' nuclear programs.

CHAPTER 7

ROK-U.S. Cooperation in Advancing Nuclear Nonproliferation, Security, and Safety Objectives

The success of nuclear power in meeting global energy and climate needs demands that both governments and the nuclear industry take the steps required to ensure public confidence that the risks associated with the civil use of nuclear energy are being minimized. These steps must be directed at three interrelated risks: (1) the proliferation of nuclear weapons to additional states, (2) the failure to ensure the safety of nuclear facilities and operations, and (3) the theft of nuclear materials and the sabotage of nuclear facilities and nuclear materials by subnational actors such as terrorists or criminals. Unless all three risks are adequately addressed, governments will not license nuclear exports or imports, the public will oppose the development of nuclear power, and the nuclear industry and financial institutions will not gamble on investing the large sums needed to build and operate nuclear facilities.

The failure to deal effectively with all these risks is a threat not only to the future of nuclear energy but, more important, to international peace and security. Although nonproliferation, nuclear security, and nuclear safety are separate areas of concern, they are closely interrelated—for example, the material accountancy and control measures of IAEA safeguards are an important component of nuclear security, and the physical protection of nuclear facilities is critical to their safe operation. Thus, inadequacies in one area could adversely affect the effectiveness of another.

The ROK and the U.S. have a number of policy tools to strengthen nonproliferation, nuclear safety, and nuclear security, ranging from diplomacy and nuclear arms reductions to sanctions and even military action. Civil nuclear trade is one of these tools, and the relationships flowing from it can give the American and South Korean governments as well as their nuclear industries an opportunity to advance the nuclear nonproliferation, safety, and security agendas in several ways:

- Intergovernmental nuclear cooperation agreements and other bilateral instruments, such as MOUs and diplomatic notes, offer the opportunity to persuade other countries to assume legal obligations or political commitments, or to take diplomatic action in all three areas.
- Agency-to-agency and laboratory-to-laboratory contacts offer invaluable opportunities to conduct joint R&D projects in order to improve technologies for strengthening safeguards, safety, and security systems; to educate cooperating partners on the importance of these issues, and to advise and assist them in establishing their own effective nonproliferation, export control, safety, and security systems; and to assist partners to implement such measures in the their own national laws, regulations, and practices.
- The relationships that private American and South Korean industries forge with their

foreign customers give them similar opportunities for education and assistance in these areas.

This chapter proposes steps that the ROK and U.S. governments, as well as their respective nuclear industries, could take—either unilaterally or in collaboration with each other, and with other nuclear-exporting states and international institutions, such as the IAEA—to ensure that international civil nuclear trade and national civil nuclear programs are carried out under the highest standards for nuclear nonproliferation, security, and safety.

These steps will vary from country to country. Nations with advanced nuclear programs and lengthy experience with nuclear matters will most likely not require American governments and industries to employ a sufficient number of well-trained nuclear professionals; to establish laws, regulations, institutions, assistance from the U.S. or the ROK in establishing or implementing export control, nuclear safety, or security systems. Nonetheless, new or strengthened bilateral nuclear relationships with such countries may offer opportunities to exchange information, engage in joint R&D, and forge common policies on key issues. Other countries that are just launching their nuclear programs and lack the nuclear experience, the institutions, and the infrastructure for implementing nuclear power programs will be able to benefit significantly from the advice and assistance of the ROK and good practices to control their nuclear exports; and to ensure the safety and security of their nuclear materials and facilities.

In some cases, the U.S. or the ROK may work separately with trading partners to advance nonproliferation, safety, and security goals. In other cases, particularly when American and South Korean firms are involved in joint projects in third countries, the two nations could find it useful to work collaboratively on the same issues. In still other cases, they could find it most appropriate to steer their cooperating partners to participate in the various programs offered by the IAEA, which most developing countries view as the institution most suitable to assist them in establishing a nuclear infrastructure, including systems for nuclear exports, safety, and security.

The new U.S.-ROK peaceful nuclear cooperation agreement should open up fresh opportunities for the two countries to work together to strengthen all three areas of nonproliferation, nuclear safety, and nuclear security. Toward this end, the two governments should set up a standing consultative body under the auspices of their cooperation agreement. This body would meet at least annually and would provide for regular, high-level exchanges of views on and coordination of polices in all these areas, as well as the implementation of the U.S.-ROK peaceful nuclear cooperation agreement.

Nonproliferation

South Korea and the United States have long shared a strong interest in preventing the spread of nuclear weapons. Both countries adhere to and have worked hard to strengthen the key elements of the global nonproliferation regime, including the NPT, IAEA safeguards, and the multilateral nuclear export control mechanisms—the guidelines of the Zangger Committee and the Nuclear Suppliers Group.

In addition, the ROK and the U.S. have worked together closely in confronting the threats posed by individual countries aspiring to acquire nuclear weapons. Most significantly, they have opposed the threat posed by the North Korean nuclear programs, both bilaterally and in the now-suspended Six Party Talks, and continue to press for that country's denuclearization. The foundation of their common strategy toward the North Korean nuclear threat is the U.S.-ROK Mutual Defense Treaty. Both states have also made efforts to halt North Korean efforts to export sensitive technology to other states, including through the participation in the Proliferation Security Initiative (PSI)—an informal understanding in which participating

states agree to undertake effective measures, either alone or in concert with other states, to interdict the transfer or transport of weapons of mass destruction (WMD), their delivery systems, and related materials to and from states and nonstate actors of proliferation concern. Although not solely directed at North Korea, the Proliferation Security Initiative has made Pyongyang's illicit trade in components and technology of WMD to other states a key target of that effort. The ROK has also pressured Myanmar (Burma) to sever its military links with North Korea if it expects to receive assistance from, and enjoy strong commercial links with, the ROK.

In response to Pyongyang's nuclear and ballistic missile activities, the UN Security Council has adopted four resolutions imposing sanctions on North Korea. These resolutions restrict North Korea from importing conventional weapons, luxury goods, and materials to develop its nuclear and missile programs; impose an asset freeze and travel ban on those people and entities that are tied to its nuclear program; prohibit financial transfers or loans that could be used to enable it to further develop its nuclear weapons and ballistic missile stockpiles; and authorize other countries to inspect and detain cargo passing into or out of North Korea through their territory on land, sea, or air, if they suspect that the cargo is being used to develop nuclear weapons. Both the ROK and the U.S. have strongly supported and faithfully implemented these resolutions.

The ROK has played a significant role in global efforts to contain the threat posed by Iran's nuclear program by adopting a wide range of economic sanctions against Tehran—especially by sharply reducing its imports of Iranian crude oil, by refusing to engage in transactions with sanctioned Iranian banks, and by retaining Iranian revenues from reduced crude oil sales in restricted South Korean accounts rather than repatriating them to Iran. In its bilateral contacts with Tehran, Seoul has also given consistent diplomatic support to a negotiated solution to the Iranian nuclear threat.

Efforts such as these have contributed significantly to a robust nonproliferation regime, but the threat of nuclear proliferation remains, and the ROK and the U.S. need to maintain their efforts to ensure the continued effectiveness of nonproliferation efforts, and to address ongoing and new aspects of this threat. One of the key risks facing the nonproliferation system is that countries might illicitly and clandestinely acquire nuclear technology from abroad to develop nuclear weapons. There is little doubt that the international nuclear trade has assisted some countries to acquire a nuclear weapons capability, often due to a lack of adequate export controls. Some countries have sought to use their civil nuclear programs, including their cooperation with other states, as a cover while they develop nuclear weapons. Countries with ambitions to possess nuclear weapons usually have used clandestine means to acquire both dual-use items and sensitive nuclear technology, such as those for enrichment and reprocessing, sometimes in violation of their NPT obligations. The most notorious example of this phenomenon is the clandestine network of A. Q. Khan, the "father" of Pakistan's nuclear bomb, which transferred enrichment know-how and weapons design information to Iran, Libya, North Korea, and possibly other countries.

As civil nuclear power grows, and particularly as it spreads to new countries, one of the key challenges facing the United States and South Korea as nuclear exporters is to ensure that this projected growth in civil nuclear power, if actually realized, will not lead to the proliferation of nuclear weapons. An indispensable aspect of meeting this challenge is to maintain and strengthen the nonproliferation controls and conditions on their civil nuclear trade, as well as to assist their cooperating partners to establish effective controls on their exports of nuclear and dual-use items. Areas of particular importance include:

- Ensuring the adequacy of their own nuclear export control systems, especially (1) preventing illicit trade and smuggling in nuclear and

dual-use items, and (2) blocking the spread of sensitive nuclear technology.

- Assisting their cooperating partners, as well as other states, particularly those with little nuclear experience, to establish effective controls on their nuclear and dual-use exports.
- Supporting the multilateral nuclear export control systems to ensure that all the major suppliers are playing by the same rules and that the guidelines of these systems keep pace with technical and political developments.
- Supporting the IAEA safeguards system, especially by assisting new nuclear states to set up national nuclear material accounting and control systems and cooperating with the IAEA in implementing their safeguards responsibilities.

Ensuring Effective Domestic Export Controls

Both the ROK and the U.S. need to ensure that their export control systems remain effective. As a relative newcomer to the international nuclear market, South Korea may face more challenges in this respect than does the United States, which has been a nuclear exporter for many decades. Until recently, South Korea's nuclear expertise has been largely confined to building its domestic civil nuclear power and R&D programs, and it has only recently been applied to the international market with its sale of nuclear reactors to the United Arab Emirates. *The ROK has adopted the nuclear export guidelines of the Zangger Committee and the Nuclear Suppliers Group but has limited experience in implementing nonproliferation assurances and controls as a nuclear supplier.*

Most experts in the South Korean nuclear field work in industry and the scientific community, and the ROK has limited numbers of government officials specializing in nonproliferation.[244] But as Seoul comes to play an increasingly important role in the global nuclear market, it should ensure that its professional expertise and resources are sufficient to meet its export control and related responsibilities. The U.S. also needs to ensure that it assigns appropriate priority and allocates adequate resources to export controls and related customs and intelligence functions in the midst of a severe fiscal environment of likely federal budget cuts.

Two issues that demand special attention from those responsible for export controls in the ROK and the U.S. are preventing the clandestine procurement of items on the international market by countries wishing to acquire a nuclear weapons capability and halting the spread of enrichment and reprocessing capabilities.

Preventing Clandestine Procurement in the U.S. and the ROK

Pakistan, Iraq, and Iran were particularly effective in clandestinely obtaining many items that were useful for developing their nuclear weapons programs from the major nuclear suppliers. As the major nuclear exporters progressively tightened their export controls, these countries were able to circumvent these controls—by manufacturing the needed equipment themselves, by using illicit trafficking and smuggling techniques, or by resorting to newly emerging suppliers that had weak or no export controls. Iran, Pakistan, and North Korea continue to actively pursue clandestine nuclear procurement efforts.

A recent study by the Institute for Science and International Security (ISIS) concluded that clandestine procurement could emerge as one of the most significant global challenges in combating the future spread of nuclear weapons.[245] The ISIS report made 100 specific recommendations in 15 broad policy areas that the United States should implement to mitigate or eliminate future threats posed by illicit nuclear trade. These recommendations included promoting awareness of the threat posed by illicit trade, improving controls on sensitive and classified information, stopping the flows of money

to support the illicit trade, prosecuting smugglers more vigorously, and improving methods to detect smuggling.

One of the main challenges facing any nonproliferation system is to stay ahead of the often-resourceful methods of aspiring nuclear weapon states to obtain items clandestinely for nuclear weapon programs. The U.S. and the ROK should:

- Ensure that they have in place adequate systems—including laws, regulations, and adequate intelligence and customs and law enforcement resources—to thwart attempts to illegally procure nuclear and dual-use items and technology from American and South Korean companies;
- Share information with each other as well as other relevant states when faced with clandestine procurement efforts; and
- Closely collaborate with their private firms to halt illegal efforts to obtain dual-use items.

To facilitate such cooperation, they should set up a bilateral consultation mechanism to exchange intelligence, share expertise, and coordinate efforts to conduct cooperative interdiction operations.

A number of studies have called for governments to work with the nuclear industry to develop internal compliance systems. The IAEA's 2008 *Report of the Commission of Eminent Persons on the Future of the Agency* ("Agency" meaning the IAEA) recommended that "governments and private firms with sensitive technologies should strengthen their partnerships to help these firms build strong internal compliance programs and give them incentives to provide key information on suspicious inquiries and procurements."[246] ISIS has pointed to a model for a corporate internal compliance mechanism based on a system created by the Leybold Company in Germany in the early 1990s.[247] The U.S. and ROK should consider initiating programs to help their industries establish programs to ensure that their companies do not allow their products and services to be diverted to the nuclear programs of countries seeking nuclear weapons.

ISIS has also suggested that countries educate their industries on these matters, and has pointed to national programs of industry outreach and education, such as those used by the U.K. and Japan.[248] One study of American companies concluded that the private sector—including manufacturers, consultants, trading companies, freight forwarders, export-import brokers, financial institutions, and other entities involved in selling or transferring nuclear or dual-use goods and services—has a role to play in preventing illicit trade, and that the adoption of industry self-regulation and best practices could make a critical contribution to fulfilling this role. Industry information can be especially timely and accurate because companies are in direct contact with the users of the goods and technology that could be illicitly diverted throughout the supply chain.[249] This will require close government-industry collaboration, particularly in ensuring the implementation of dual-use and catchall controls.[250]

Assisting Other States to Prevent Clandestine Procurement

In addition to maintaining their own nuclear controls to prevent illicit procurement, both the U.S. and the ROK should assist their cooperating partners, particularly those beginning nuclear programs, to set up and implement effective nuclear export control systems. The ISIS report cited above concluded that "the most problematic future suppliers could emerge in developing countries." Beginning in the 1980s, several new suppliers of nuclear materials, equipment, and technology emerged on the international market. The increased availability of information, together with technical advances, has the potential to enable many new countries to become suppliers of equipment and components significant for a nuclear weapons program. A good illustration of this problem is the case of a firm in Malaysia that participated in the Khan network by making

thousands of high-precision aluminum centrifuge parts, including the casings and molecular pumps that were being shipped to Libya when they were found on the ship MV *BBC China* in October 2003.[251] Today, most countries are able to produce one or more items from the ZC's Trigger List or the NSG's Dual-Use List, but many of them do not adhere to the export guidelines of the ZC or the NSG. Any country that has an industry such as steel, chemistry, new materials, electronics or machine tools is capable of contributing to a nuclear weapons program through its exports. Thus, many states have acquired the capability to provide significant assistance to a nuclear weapons program but lack the legal, regulatory, and enforcement systems, the resources, and, in some cases, the will to implement effective nuclear export controls.

An important step to obligate states to adopt effective export controls was the UN Security Council's 2004 adoption of Resolution 1540, which calls on countries to put in place "appropriate effective measures to account for and secure" WMD-related items in production, use, storage, or transportation and to "maintain appropriate effective physical protection measures" of said items. The resolution's primary purpose was to deny such items to nonstate actors, but it also obliges states to establish effective export controls. The resolution also established a 1540 Committee and a group of experts assigned to the committee to monitor compliance with the resolution, including by reviewing country reports. In 2011, UN Security Council Resolution 1977 extended the mandate of the 1540 Committee for 10 more years. The 1540 Committee has organized or supported 38 regional or thematic workshops, organized meetings of civil society representatives, and collaborated with industries that could undertake practical measures related to implementation of the resolution.[252] The committee does not itself provide assistance to countries, but instead identifies countries in need of assistance and links them with available sources.

Although the adoption of UN Security Council Resolution 1540 constitutes a major new legal instrument to halt the spread of WMD, its implementation 10 years after adoption faces continuing obstacles, including a lack of understanding of the importance of the issue among governments and civil society, and insufficient resources available to countries to comply with its requirements. Inadequate expertise and personnel have prevented some governments from producing the comprehensive reports required by the resolution to document the steps taken to meet their obligations. Some countries clearly need assistance to build up their capacity to implement the resolution.[253]

UN Security Council Resolution 1540 calls on nations that are able to do so to provide expertise or financial, organizational, or technical assistance to those governments requesting such help. The U.S. and South Korea should work individually or together with their nuclear trading partners to provide them with assistance in implementing their obligation to establish effective export controls. Depending on the needs of the individual country, various types of assistance may be appropriate, including funding, legal advice or model laws and regulations, the loaning of staff members, training for customs agents and licensing officers, and the provision of technology. There is also a role to be played by American and South Korean nuclear firms in working with and educating their customers on the importance of adopting company policies and practices that will help prevent illegal exports.

In the case of the United States, the State Department's Office of Export Control Cooperation is devoted to assisting foreign governments to ensure that their strategic trade control systems meet international standards. In particular, the office helps foreign governments establish independent capabilities to regulate transfers of items related to WMD, conventional arms, and related dual-use items, and to detect, interdict, investigate, and prosecute illicit transfers of such items. The office engages in dialogue, provides training, and donates equipment to foreign government to achieve these objectives. DOE also has programs

devoted to strengthening the capability of foreign governments to deter, detect, and interdict illicit trafficking in nuclear and other radioactive materials across international borders and through the global maritime shipping system, and to help build foreign partners' nuclear forensics capabilities to help deter illicit trafficking in nuclear and radiological material.

In the case of South Korea, the Nuclear Safety and Security Commission (NSSC), an independent regulator, has responsibilities for licensing, inspections, enforcement, incident and emergency responses, nonproliferation and safeguards, export/import controls, and physical protection. The NSSC is responsible for the implementation of strategic trade controls under the Foreign Trade Act, and the Korea Institute of Nuclear Nonproliferation and Control (KINAC) provides technical support to NSSC for matters related to the efficient implementation of safeguards, export and import controls, and security related to nuclear materials and facilities. KINAC also has the responsibility to enhance the professional capabilities of South Korea's nuclear industry in all these areas. And KINAC's Nuclear Export Control Division has an active outreach program, and conducts seminars and workshops in order to improve South Korean companies' compliance with, and understanding of, the country's strategic trade control law. Internationally, South Korea has also agreed to share its experience in nuclear trade controls, safeguards, and physical protection with the UAE.[254]

American and South Korean nuclear firms also have an important role to play in working with and educating their customers on the importance of adopting company policies and best practices that will help prevent illegal exports. The U.S. and South Korean governments should encourage their private companies to implement programs to assist their customers in adopting effective export control practices.

A key element of these efforts will be to educate new nuclear states that export controls are not meant to deny countries equipment and technology for legitimate peaceful purposes. Rather, they are intended to facilitate commerce for such purposes by providing assurances to exporters and the international community that such equipment and technology will be used for peaceful purposes in a transparent manner.

The U.S. and the ROK should also seek to persuade their cooperating partners that are capable of producing items of potential proliferation concern either to adopt export policies that are consistent with the guidelines of the ZC or the NSG, or to become members of one or the other of these multilateral export control systems.[255] They should also persuade countries to enforce the UN Security Council's sanctions resolutions against countries engaged in illicit trade, such Iran and North Korea.

Preventing the Spread of Enrichment and Reprocessing

An especially important objective of both countries should be preventing the spread of enrichment and reprocessing. South Korea could institute new and strengthened nonproliferation measures in its peaceful nuclear cooperation agreements that will more closely parallel those that the U.S. requires. For example, South Korea requires consent rights for reprocessing in its agreements with some countries but not others. Reportedly, it does not require consent rights on reprocessing in its cooperation with "advanced nuclear states," such as Argentina, Brazil, Canada, China, France, Germany, Russia, and the United Kingdom.[256] In all of Seoul's future peaceful nuclear cooperation agreements—and particularly those with developing countries in regions of proliferation concern—it should consistently require consent rights on reprocessing and alteration in the form or content of material used or produced in South Korean–supplied nuclear reactors or their significant equipment.

The United States already has a tough policy of discouraging the spread of reprocessing and enrichment by requiring consent rights in all its

cooperation agreements. In addition, it has obtained a legal commitment from two cooperating partners—the UAE and Taiwan—to forswear the acquisition of these technologies. However, some proposals risk overreach. For example, recent, well-intentioned efforts by some in the U.S. Congress and the nonproliferation community to require that all future cooperation agreements contain a legal commitment by the cooperating parties to forswear enrichment and reprocessing capabilities could seriously damage the prospects for U.S. nuclear exports and could deprive the United States of the nonproliferation influence that comes with nuclear cooperation. Other suppliers are not going to require such demanding export conditions, and most consumer countries are likely to reject U.S. demands that they believe deny them their rights or legitimate peaceful commercial opportunities. Thus, any such policy should be applied very carefully and selectively.

As discussed above, some countries in unstable regions such as the Middle East have expressed interest in developing a civil nuclear program. If these countries proceed with their civil nuclear programs, they are likely to be small and restricted to one or two research or power reactors for the foreseeable future. It would make no economic sense for these countries to acquire either enrichment or reprocessing plants. Moreover, the presence of these sensitive nuclear technologies in such a politically volatile area would threaten regional stability, and seriously risk the threat of proliferation. The U.S. and South Korea need to closely coordinate their civil nuclear cooperation policies to dissuade these countries from acquiring enrichment or reprocessing capabilities. It would also be important to require additional stringent nonproliferation conditions. For example, some experts have advocated that any agreement for cooperation with Saudi Arabia should include a requirement that the Kingdom adopt the IAEA Additional Protocol, that it rescind its Small Quantities Protocol,[257] and that it conclude up-to-date subsidiary arrangements to its safeguards agreement with the IAEA in order to give the IAEA design information about nuclear installations as soon as the decision is made to build them.[258]

Both countries could explore alternatives to indigenous enrichment and reprocessing in the Middle East. KHNP's investment in Areva's Georges Besse II enrichment plant offers a good example of a multinational approach to securing a reliable supply of enriched uranium. In addition, South Korea's supply of nuclear reactors to the UAE could provide Seoul with the opportunity to cooperate with the UAE on its search for spent fuel and nuclear waste management options.[259] The UAE is looking at options for long-term spent fuel storage and a geological repository, possibly in cooperation with other states in the Gulf region.

The ROK is considering its options for spent fuel management, and there is potential for a fruitful exchange of views on this key issue facing both South Korea and the United States, which they should share with their nuclear trade partners. The ROK could also explore the study of regional spent fuel storage and waste management in East Asia. The August 2014 ruling by the NRC that spent fuel may be stored safely for an indefinite period should help support the technical feasibility and political acceptability of using long-term spent fuel storage either on a national or regional basis as an alternative to reprocessing.

Sustaining and Strengthening Multinational Export Control Regimes

The U.S. and South Korean export control systems, no matter how effective, cannot by themselves prevent the spread of nuclear weapons. Without an agreement on the common rules of the game among the key nuclear exporters, supplier countries would be tempted to further their competitive position in the international market by minimizing the nonproliferation conditions on their nuclear exports. Nuclear aspirants would be able to play one supplier against another to obtain nuclear equipment and technology on minimal nonproliferation terms. In order to address these concerns,

the major nuclear suppliers have established two multilaterally coordinated nuclear export control regimes.

The first is the so-called Zangger Committee, which was established in 1974 in order to implement article III.2 of the NPT, as described throughout this report. Article III.2 obliges states that are party to the NPT to require IAEA safeguards on their exports of nuclear materials and equipment. The second multilateral arrangement is the NSG, whose guidelines were developed in response to several nonproliferation crises in the 1970s, and which has also been described throughout this report. The NSG adopted the ZC's Trigger List of nuclear items, but it also applied conditions to nuclear exports that went beyond the requirements of the NPT and ZC, and that included assurances of adequate physical protection and special restraints on the export of sensitive nuclear technology—that is, enrichment, reprocessing, and heavy water production technology. Both these multilateral systems have evolved over time in order to keep pace with technical innovations and political developments, and in response to various challenges to the nonproliferation system, including the risks presented by the spread of enrichment and reprocessing facilities and the successful operation of clandestine procurement networks by countries aspiring for a nuclear weapons capability.

Today the NSG faces two major issues. One is to remain ahead of the game by clarifying and expanding the nuclear and dual-use items on its control lists in order to keep abreast of technical developments and the sometimes-creative methods that would-be proliferators have used to exploit loopholes in the export control regimes of supplier states. The ZC has clarified and updated its nuclear Trigger List. Today, the expanded lists are essentially the same. The NSG has recently updated its Trigger and Dual-Use Control lists. The 2013 NSG Plenary in Prague and the IAEA published all 54 agreed amendments in revised IAEA documents INFCIRC/254/Part 1 and INFCIRC/254/Part 2 on November 13, 2013. The U.S. and South Korea should continue to ensure that the ZC and the NSG regularly update these lists.

The second major challenge facing the NSG is to ensure that its members are abiding by its guidelines. In 1993, the NSG adopted a new guideline to supply Trigger List items only if the recipient non–nuclear weapon state has a comprehensive safeguards agreement in effect with the IAEA—that is, if it placed all peaceful nuclear facilities under the IAEA's safeguards. This decision remedied a major deficiency in the safeguards system that allowed some countries to develop parallel peaceful and military programs. However, this 1993 guideline applied only to new supply commitments, not existing ones—the so-called grandfather clause. Unfortunately, China has been abusing this loophole as its justification for supplying civil nuclear reactors to Pakistan—a country that is not a party to the NPT and that has no comprehensive safeguards agreement with the IAEA. When Beijing joined the NSG in 2004, it provided a formal "declaration of existing projects," in which it identified its 1991 cooperation agreement with Pakistan, under which it had supplied a 300 MW reactor at Chashma, and had just undertaken to supply an additional 325 MW reactor at the same location. The Chinese claimed that the supply of these reactors did not constitute a "new" supply commitment, and therefore, was grandfathered under the NSG's comprehensive safeguards guidelines. This was a dubious claim at the time because the 1991 Chinese-Pakistani pact was a general framework agreement and reportedly did not contain an actual commitment to supply reactors at Chashma. In addition, China did not mention grandfathering any more reactors under the 1991 agreement. Now, China is supplying Pakistan with three new reactors that are clearly not covered by the 1991 agreement, and it is once again flouting the NSG's guideline on comprehensive safeguards.

China's behavior threatens to undermine the comprehensive safeguards norm as well as the NSG's integrity. The U.S. and South Korea should make clear that Chinese behavior violates Beijing's NSG

commitments, and insist that China seek an exemption from the NSG for such exports to Pakistan and then firmly reject that request. As Seoul and Washington engage in nuclear collaboration with Beijing, they also need to obtain solid assurances from the Chinese authorities that their nuclear exports to China will not be retransferred to Pakistan or to any other non–nuclear weapon state that does not have a comprehensive agreement in effect with the IAEA. Even though exports of dual-use items do not require comprehensive safeguards as a condition of supply, the U.S. and the ROK should obtain similar guarantees for the dual-use items that they supply to China.

Support for the IAEA Safeguards

IAEA safeguards are a core element of the global nonproliferation regime, are essential to the effective implementation of the NPT, and are a necessary condition for the development of civil nuclear programs and international commerce. Over the years, the IAEA's safeguards system has been considerably strengthened as the Agency has adopted new safeguards techniques and has acquired additional authorities to detect the diversion of nuclear materials to nonpeaceful purposes. However, the Agency's safeguards system faces many political, technical, and political challenges. The ROK and the U.S. should utilize their nuclear trading relationships to help strengthen the IAEA's safeguards systems in various ways.

Resources. In his address to the IAEA's 58th General Conference in September 2014, Yukiya Amano, the IAEA's director-general, said that the Agency is likely to face tough budget constraints for some years to come, that the demand for the services of the IAEA continues to grow, and that it is not possible to meet these growing needs within existing financial means.[260] The U.S. and the ROK need to continue their efforts, including through their contacts with their nuclear trading partners, to ensure that the IAEA has the financial, political, and technical support it needs to meet the rapidly growing demands on its nuclear safeguards system.

Support for the Additional Protocol. The ROK and the U.S. should also take advantage of their roles as major nuclear exporters to make adherence by recipient states to the AP to the IAEA's comprehensive safeguards agreements a condition of nuclear supply and a universally accepted international norm. The 1991 revelation of a significant clandestine nuclear weapons program in Iraq, a party to the NPT with a comprehensive safeguards agreement in effect, underscored the limitations of IAEA safeguards as they were being applied at the time. In particular, they were too focused on verifying nuclear activities at declared facilities. The IAEA needed more information about, and access to, nuclear activities at undeclared locations in order to ensure the completeness as well as the correctness of a state's declarations.

In response, the IAEA undertook a major reform of its safeguards system when the Board of Governors adopted the Model Additional Protocol (INFCIRC/540, Corrected) in 1997. Under this protocol, the IAEA has the right to increased information and access to all aspects of a state's nuclear fuel cycle—from uranium mines to nuclear wastes and to locations where nuclear material intended for nonnuclear uses is located. Among other things, the AP gives "complementary access" rights to the IAEA and its inspectors. For example, access is possible to any place on a "site," or to mines, or to nuclear-related locations where no nuclear material is present, such as sites where related R&D or manufacturing activities are performed, in order to ensure the absence of undeclared activities. The AP also permits environmental sampling on either a location-specific or, under certain conditions, wide-area monitoring basis.

The AP constitutes a major strengthening of the IAEA's safeguards system. However, it is not self-executing, and the IAEA must negotiate an agreement with each state in order to apply the broadened safeguards measures envisioned by the AP. As of August 6, 2014, 127 states have adopted the AP. But several key states with nuclear facilities or with plans to implement new nuclear programs have thus far

chosen not to adopt the AP, including Argentina, Brazil, Iran, Myanmar, Malaysia, and Thailand.

One important step in strengthening the nonproliferation regime in general and the IAEA's safeguards system in particular would be universal acceptance of the AP and its recognition as the international safeguards norm for non–nuclear weapon states. The U.S. and the ROK can help achieve this objective by requiring the AP as a condition of supply in their own civil nuclear cooperation agreements. U.S. law does not require the AP as a condition of U.S. nuclear supply under peaceful nuclear cooperation agreements, and the U.S. has been inconsistent in requiring the AP in its bilateral agreements since the IAEA adopted the Model Additional Protocol in 1997.[261] South Korea has not made the adoption of an AP a condition for nuclear exports, but has said it will support this requirement if the NSG endorses it.[262] Both countries should require new cooperating partners to adopt the AP to their safeguards agreement, and should encourage existing partners that have not adopted the AP to do so as soon as possible.

Both countries should also continue to urge the NSG to adopt the AP as a condition of supply for Trigger List items. Only limited success has been achieved on this issue thus far because some members argue that it is not required by the NPT and should therefore be a voluntary measure. The NSG did manage to agree to require the AP as a condition of supply for enrichment and reprocessing equipment and technology, but with a key exception that allows such exports when a regional safeguards approach is being applied.[263] However, the one regional safeguards system to which this exception would apply is the bilateral safeguards agreement between Argentina and Brazil, and that system falls far short of the requirements of the AP. The ROK and the U.S. should continue to press the NSG to adopt the AP as a condition of supply for all Trigger List items, with no exceptions.

The two countries should also continue efforts to have NPT parties recognize the AP as the international norm. Strong proponents of nonproliferation have been trying to persuade the NPT Review Conference to adopt the position that new nuclear supply arrangements to non–nuclear weapon states should require acceptance of an IAEA comprehensive safeguards agreement and an AP. However, some states continue to take the position that acceptance of the AP is a voluntary matter, and is not required by the NPT.

This issue is also debated at the annual IAEA General Conference, where the United States and other Western states have tried to urge the conference to adopt a safeguards resolution that recognizes the AP as the IAEA's safeguards standard for all non–nuclear weapon states. Brazil, Argentina, Iran, and Egypt routinely reject this proposal, with the result that the resolution adopted by the conference typically acknowledges the AP only as an important safeguards measure.

The U.S. and the ROK should accelerate their efforts in their nuclear trading relationships with other countries, particularly with members of the Non-Aligned Movement, and in the context of the NPT Review Conference, to endorse the AP as the verification standard under article III of the NPT and as the IAEA standard for all non–nuclear weapon states.

Safeguards assistance for new states. States embarking on a new nuclear program lack the knowledge and infrastructure to implement their safeguards responsibilities effectively. The IAEA has a number of programs to assist states in carrying out their safeguards obligations, including various guidance documents for implementing safeguards; advisory service missions to provide advice on such matters as export control, nuclear material accounting and reporting, and the establishment of a legal regulatory framework; and international and regional training courses and a safeguards trainee program addressing all aspects of safeguards implementation. One particular area of importance is the establishment of state systems of accounting and control. The effectiveness and efficiency of

IAEA safeguards depend, to a considerable degree, on the effectiveness of state and regional systems of accounting for and control of nuclear material (SSACs/RSACs) and on the level of cooperation between the IAEA and state or regional authorities (SRAs) responsible for safeguards implementation. The U.S. and the ROK should encourage and assist their nuclear trade partners to establish effective SSACs and urge them to take advantage of the various programs that the IAEA offers for training and assistance in these areas.

As a matter of policy, the United States' peaceful nuclear cooperation agreements require that its cooperating partners establish and maintain a system of accounting for and control of source and special nuclear material subject to the agreement, and that the procedures for this system be comparable to those in the model IAEA comprehensive safeguards agreement. South Korea should do the same in its agreements, if it does not already do so.

Increased information sharing with the IAEA. In 1993, the IAEA Board of Governors endorsed a voluntary reporting system on imports and exports of specified equipment and nonnuclear material. This was designed to increase the transparency of a state's nuclear program. In addition, the AP requires that states report imports and exports of Trigger List nuclear items to the IAEA. However, neither the 1993 IAEA Board of Governors' decision to endorse voluntary reporting of nuclear exports nor its approval of the AP called for reporting on exports of dual-use items or technology. When this issue was discussed at the IAEA committee negotiating the AP, many states argued that dual-use items do not qualify for regular reporting to the IAEA because they are not as significant as items on the nuclear Trigger List and are more difficult to control. Another objection was that, if the IAEA received information about the transfer of a dual-use item, it would not be able to verify its location or use in the importing country. However, Pakistan, Iran, and Iraq built their nuclear weapons programs through the extensive use of imported dual-use items.

In addition, some have argued that the IAEA may have questions from time to time about apparent inconsistencies in a country's nuclear program. If the IAEA has questions about a particular dual-use item in order to obtain a complete assessment of a particular country's program or to resolve an inconsistency, NSG member states should be willing to provide all the information needed by the IAEA on individual goods and on that country's procurement practices. Hans Blix, the IAEA's former director-general, has said that, "in comparing the information required by the Agency under the Additional Protocol and the Trigger List as elaborated by the NSG, it will be noted that the Agency does not require information about dual-use items. However, there is no doubt that greater transparency and increased cooperation among the suppliers and importers of such items will also be helpful from the perspective of the overall level of confidence in the conclusions of safeguards verification."[264]

One study has recommended that the NSG should agree that each member state should, on an individual basis and under its own responsibility, share information with the IAEA about applications to export controlled items that they have denied for reasons related to the NSG guidelines.[265] Sharing denial notifications with the IAEA should impose no additional burdens and would significantly assist the IAEA in fulfilling its mission to analyze procurement patterns and states' nuclear capabilities. Sharing such information is a national decision, but few countries will agree to do so regularly unless the NSG collectively makes this a guideline for all members. The same report has proposed that NSG members should also consider sharing information with each other and the IAEA on "informal denials" and approvals for key dual-use items.[266] Sharing such information could be based on the same principles of no undercutting and commercial confidentiality that govern the denial notification—namely, that information about denials will not be used for commercial purposes.

The *Report of the Commission of Eminent Persons on the Future of the Agency* concludes that

"all member states should provide the IAEA with the information it needs to do its job—including data on exports and imports of nuclear and related technologies, export denials, inquiries, and suspicious procurement attempts; information that states may have available from other sources; relevant police information, as appropriate; and more."[267] It also states:

> *While the universalization of CSAs and APs is a key goal, it will also be important to continue tackling the limitations identified in the existing legal framework. Unaddressed, these limitations can hamper the process of assessing the nuclear programmes of States. For example, the list of equipment and materials for which States are required to provide export and import information under an AP could be expanded to reflect the evolution of nuclear technology as well as address items likely to be involved in the clandestine nuclear trade. Moreover, various voluntary reporting schemes providing relevant information not covered under existing agreements will need to be evaluated to see how the current irregular and limited reporting by States could be enhanced.*[268]

One expert on IAEA safeguards puts it this way:

> *Export control information, especially with regard to denials of dual use items that could be serving proliferation-relevant activities, is potentially very significant to the IAEA's ability to draw safeguards conclusions for a state, whether it has only a comprehensive safeguards agreement or an additional protocol in force as well. Many factors go into the Agency's process of developing a state-level safeguards approach, most of which are beyond the scope of this presentation. But having information regarding the interest of a state to acquire certain components that could be of proliferation significance, and that did not match the declarations made by that state regarding its current (or in the case of an additional protocol state, its future) nuclear development program, whether granted or denied by the exporting state, would put the IAEA in a better position to raise questions and to make evaluations with potential compliance implications.*[269]

The IAEA has reported that a number of member states voluntarily provided the Agency with information concerning 62 denied nuclear trade-related procurement inquiries over the last year, and that this information was used to assess the consistency of nuclear activities declared by states to the IAEA.[270] The U.S. and the ROK should provide the IAEA with information on their dual-use nuclear-related exports, particularly export denials, and should urge their trading partners to do the same.

Compliance with safeguards agreements. Perhaps the most serious challenge to the safeguards system has arisen from the refusal of certain countries to comply with their comprehensive safeguards agreements with the IAEA. These have included Iraq and Libya in the past, and currently include North Korea and Iran. The U.S. and the ROK should continue to stress the importance of states complying with their safeguards obligations, and to support the efforts at the IAEA General Conference and the NPT Review Conference to demand that states such as Iran and Syria cooperate with the IAEA to remedy their noncompliance with their safeguards obligations, and to urge North Korea to permit the verification of its denuclearization. In promoting these objectives, they should make use of their ties with their partners in civil nuclear trade.

Safety

The Fukushima nuclear accident of 2011 has focused the attention of governments and the industry on strengthening nuclear safety around the world. Both the U.S. and the ROK have undertaken steps to bolster the safety of their own nuclear installations, and both countries have substantial

safety cooperation programs with other countries. The ROK and the U.S. should utilize the opportunities provided by their nuclear cooperation agreements and industry-to-industry links to educate their cooperating partners on the importance of nuclear safety and, where appropriate, to provide bilateral safety assistance and advice to such states. Both countries should also continue regional efforts to strengthen nuclear safety and support the IAEA in its various programs in this area.

Bilateral Safety Efforts

Both countries should encourage their cooperating partners to take advantage of the safety assistance and cooperation programs of their relevant safety agencies. In the case of the U.S., the NRC has an extensive program that provides advice and assistance to both international organizations and other countries on developing effective regulatory organizations, and on enforcing rigorous safety standards. It maintains close working relations with nuclear agencies in more than 35 countries, exchanges operational safety data and other regulatory information, and provides safety and safeguards advice, training, and other assistance to countries that seek the United States' help in improving their regulatory programs. The NRC originally worked primarily with major nuclear power countries but has since expanded its cooperation to include countries with small nuclear power programs, as well as some launching new nuclear programs. The NRC's information exchange arrangements should be used to the fullest extent to provide health and safety assistance to less-developed countries in their attempts to prevent accidents, and to develop and improve their regulatory capabilities and their nuclear safety infrastructure.

The Korean Institute of Nuclear Safety (KINS) provides assistance to the UAE and Jordan in the nuclear safety area. Both the ROK and the United States should press their trading partners to establish a strong, financially and politically independent nuclear regulatory system, to invite peer reviews of safety planning, and to conduct regular performance testing of nuclear safety and disaster management preparations.

Regional Safety Initiatives

South Korea has taken an important initiative to improve nuclear safety in Northeast Asia. On August 15, 2014, South Korean president Park Geunhye proposed a nuclear safety consultative group to promote and ensure nuclear safety in Northeast Asia.[271] The forum is to be led by Seoul, Beijing, and Tokyo, while involving the participation of the U.S., Russia, eventually North Korea, and Mongolia.

South Korea hosted the Northeast Asia Nuclear Safety Symposium—the second Top Regulators Meeting+ (TRM+)—in Seoul from November 26 through 28, 2014, to discuss ways to promote safety in Northeast Asia.[272] The symposium brought together about 200 government officials, including those from the U.S., China, and Japan, as well as experts from the private sector. The ROK should consider whether this regional forum could be extended to other states, particularly its nuclear trading partners that are considering or beginning nuclear programs, for example, Indonesia and Malaysia.

South Korea is providing assistance in the areas of nuclear safety, security, and nonproliferation to countries in the Asia-Pacific region, particularly through its nuclear security educational training center established in 2014. KINAC is enhancing its support for countries that are interested in developing nuclear energy programs.

Treaties Related to Nuclear Safety

The U.S. and South Korean governments, as well as their private companies, should take advantage of the nuclear relationships they have with their nuclear cooperation partners to urge them, if they have not already done so, to ratify and implement relevant international treaties and conventions, including:

- the Convention on Nuclear Safety (and make public annual national reports under the convention),
- the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, and
- the Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency.

The IAEA

Many states look to the IAEA for advice and assistance on nuclear safety matters. The IAEA has long had safety programs, which include advice on safety standards, a system of safety fundamentals, safety requirements, and safety guides. Following the disaster at the Fukushima Daiichi nuclear power plant, the IAEA Board of Governors adopted a draft IAEA Action Plan on Nuclear Safety in September 2011 that was unanimously endorsed by the General Conference that same year. The purpose of the Action Plan is to define a program of work to strengthen the global nuclear safety framework, including emergency preparedness and radiation protection.

The IAEA has reported that it has made progress in implementing the Action Plan in various areas, including assessing safety vulnerabilities of nuclear power plants, strengthening the Agency's peer review services, improving emergency preparedness and response capabilities, strengthening and maintaining capacity building, and protecting people and the environment from ionizing radiation. It has also made progress in sharing and disseminating the lessons learned from the Fukushima accident. The ROK and the U.S. should press their trading partners to develop cooperative relationships with the IAEA's Department of Nuclear Safety and Security, and to invite IAEA operational safety review teams to help provide relevant advice and assistance on nuclear safety matters. The IAEA has pointed out that the success of the Action Plan's implementation requires the full cooperation and commitment of member states. The U.S. and ROK could make extrabudgetary contributions to the IAEA safety program, particularly for the implementation of the Action Plan.

Liability

Nuclear liability is one of the many elements of the Action Plan on Nuclear Safety adopted by IAEA member states after the 2011 Fukushima accident. The current international system for nuclear liability and compensation for a nuclear disaster consists of a confusing hodgepodge of different international instruments—including the Vienna Convention on Civil Liability for Nuclear Damage, the Paris Convention on Third-Party Liability in the Field of Nuclear Energy, the Joint Protocol Relating to the Application of the Vienna Convention, and the Paris Convention, the Brussels Supplementary Convention, and the Convention on Supplementary Compensation for Nuclear Damage (CSC). Several states with large nuclear programs—such as China, South Korea, Japan, and India—are not party to any international nuclear liability convention and rely on their own national legislation. Most nuclear suppliers have found India's national liability law woefully inadequate, a fact that has inhibited nuclear trade with that country. More than half the world's reactors are outside the Paris and Vienna conventions.[273] The Fukushima nuclear disaster has gone a long way to raise global awareness about the inadequacy of the current situation, and the need to bring some coherence and consistency to the current liability landscape.

According to the World Nuclear Association, the failure to devise an effective global nuclear liability system has been the result of differences between the United States and France, whereby Paris is a proponent of the Paris and Joint protocols, and the U.S. supports the CSC. However, the two countries are trying to resolve this disagreement and are encouraging more countries to sign up to the revised Paris and Brussels conventions or to the revised

Vienna Convention, the Joint Protocol, and the CSC in particular. An 'initial step' envisaged is the CSC's entry into force.[274]

The U.S. has strongly supported the CSC's entry into force as a key step in rectifying the deficiencies and confusion in the international nuclear liability system. The CSC has two main objectives. The first is to establish a worldwide liability system in which all states may participate. (The CSC is open not only to countries that are party to an existing nuclear liability convention, such as the Vienna Convention on Civil Liability for Nuclear Damage, but also to other countries, provided that their national legislation is consistent with the uniform rules on civil liability laid down in the annex to the CSC.) The second objective is to increase the amount of compensation available in the event of a nuclear incident by establishing a minimum national compensation amount and an international fund to which contracting parties will be expected to contribute in the event of a nuclear accident.

The Vienna Convention now has 18 signatories and five contracting states, but it will not enter into force until at least five states with a minimum combined total of 400,000 MW (thermal) of installed nuclear capacity become parties. Thus far, five states with a total combined installed nuclear capacity of 308,000 MW (thermal) have ratified the CSC. Japan and Canada have recently announced their intention to do so. These ratifications would bring the CSC into force, almost doubling the number of civil nuclear power plants covered by nuclear liability treaties. The U.S. has ratified the CSC, and the ROK should move quickly to do the same. Both countries, as well as their companies, should stress the importance of an adequate liability system and urge their nuclear cooperation partners to join the CSC.

Nongovernmental Organizations

The World Association of Nuclear Operators (WANO) is an international organization of nuclear power plant operators whose objective is to promote the highest possible standards of nuclear safety. Its policies emphasize effective communication and open information sharing among operators. WANO operates four main programs: peer reviews, operating experience, technical support and exchange, and professional and technical development. The U.S. and ROK governments and industries should urge foreign reactor operators to join this organization and to take advantage of its programs.

Nuclear Security

With the rise of terrorism and the interest shown by some terrorist groups such as al Qaeda in acquiring nuclear weapons and materials and in attacking nuclear facilities, nuclear security has become a topic of major international concern. The U.S. and South Korea have taken leading roles in strengthening the security of nuclear materials and facilities from theft or sabotage by nonstate actors such as terrorists and criminals. Both participate in the Global Initiative to Combat Nuclear Terrorism and the Global Partnership against the Spread of Weapons and Materials of Mass Destruction. In addition, the U.S. hosted the first Nuclear Security Summit in Washington in 2010, and the ROK held the second one in Seoul in 2012. Both participated in the third summit this year in The Hague, and they will take part in the final summit, most likely in Chicago, in 2016.

The 2010 Washington summit unanimously endorsed a nonbinding communiqué to secure global stocks of nuclear material within four years and produced a work plan detailing further steps that countries would take in the pursuit of nuclear security. The plan emphasized strengthening existing measures, such as the Convention on the Physical Protection of Nuclear Materials (CPPNM) and its 2005 amendment, the International Convention for the Suppression of Acts of Nuclear Terrorism (ICSANT), and UN Security Council Resolution 1540.[275] Other accomplishments have included securing commitments to convert civilian reactors from the use of HEU fuels to the use

of LEU fuels, and to promote measures to secure, account for, and consolidate stocks of HEU and plutonium. The 2012 Seoul Summit reaffirmed the steps outlined at the 2010 Washington summit and gave new or greater emphasis to some issues, such as the nexus between nuclear security and nuclear safety, the importance of protecting radiological sources, the need for improved security for sensitive information, and cyber security.

The 2014 Nuclear Security Summit in The Hague emphasized the need to strengthen and coordinate international cooperation in the field of nuclear security, including through bilateral and regional cooperation. It noted that "international cooperation fosters the capacity of States to build and sustain a strong nuclear security culture and effectively combat nuclear terrorism or other criminal threats." It encouraged states, regulatory bodies, research and technical support organizations, the nuclear industry and other relevant stakeholders, within their respective responsibilities, to build such a security culture and share best practices and lessons learned at the national, regional, and international levels.

The three nuclear security summits succeeded in increasing global awareness of the necessity of securing nuclear materials effectively, led to concrete steps and measurable progress in reducing the availability and improving the security of weapons-usable nuclear material, and produced specific commitments by participating countries to improve nuclear security. However, the summits have also shown that much more work lies ahead for the international community to promote the establishment of effective and sustainable national systems of physical protection, a strong worldwide nuclear security culture, and an effective international legal architecture of nuclear security.

The 2014 Hague Summit produced several documents and national statements calling for countries as well as the nuclear industry to take specific steps to strengthen nuclear security worldwide. The summit recognized the need for a strengthened international nuclear security architecture consisting of legal instruments, international organizations and initiatives, internationally accepted guidance, and good practices. Like the previous summits, it called on states that have not yet done so to become party to the Convention on the Physical Protection of Nuclear Material (CPPNM) and to ratify its 2005 amendment, and to become party to the International Convention on the Suppression of Acts of Nuclear Terrorism (ICSANT).

One of the most important accomplishments of The Hague summit was an initiative by the United States, the Netherlands, and the ROK to obtain the agreement of 35 participants to a so-called gift basket on "Strengthening Nuclear Security Implementation." The joint statement contains a commitment to embed the objectives of the IAEA's nuclear security fundamentals and the IAEA's physical protection recommendations, which are nonbinding, in national rules and regulations, and to host peer reviews to ensure their effective implementation.[276]

Also of note, the same 35 countries agreed to conduct self-assessments of their nuclear security systems, host periodic peer reviews by the IAEA's International Physical Protection Advisory Service (IPPAS), and implement recommendations identified in the reviews. If actually carried out, the commitment to the IAEA's physical protection reviews will be important to ensure that countries' physical protection laws, regulations, and practices will be assessed on the basis of international standards and will help ensure the effectiveness of the measures taken.

South Korea and the United States should consider supporting these steps in implementing their nuclear export policies and in educating their cooperating partners on the importance of physical protection of nuclear materials and facilities and, where appropriate, providing assistance to improve their partners' security systems and practices. In particular, the U.S. and South Korea should undertake the following six steps:

The first step is to encourage adherence to nuclear security treaties. The U.S. and South Korea should require that their future cooperating partners adhere to CPPNM and its 2005 amendment as well as the ICSANT, and should also encourage existing partners to do so. Unfortunately, Washington has yet to ratify these treaties and, to be credible in convincing others to adhere to these international security instruments, the United States should take immediate steps to ratify them.

The second step is to strengthen nuclear security implementation. As noted above, a number of states at the last summit committed to embed the objectives of the IAEA's nuclear security fundamentals and the IAEA's physical protection recommendations in their national rules and regulations. The U.S. and South Korea should require future cooperating partners and encourage existing ones to incorporate the IAEA's physical protection guidelines into their national laws and regulations, and to publish their relevant regulations. They should also encourage their coordinating partners to conduct self-assessments of their nuclear security systems, host periodic peer reviews by the IAEA's IPPAS missions, and implement recommendations identified in the reviews in order to provide a level of confidence to the international community that they are taking nuclear security within their borders seriously.

To do so credibly, however, Washington and Seoul will need to follow through on their own pledges and expeditiously fulfill their summit commitments by incorporating the guidelines into their national laws, and by inviting IPPAS missions to review their nuclear security systems. Both states have recently had IPPAS missions to set such an example,[277] and the IAEA has reported that these missions resulted in the identification of areas for improvement as well as of good practices, which, if shared, could be beneficial to other states.[278] The U.S. and South Korea should work toward making routine international reviews of nuclear security measures the international norm, and should encourage their cooperating partners to request IPPAS missions on a regular basis.

Both countries could also commit to provide technical and financial assistance where appropriate to their cooperating partners to help implement such commitments in coordination with the IAEA. The U.S. and the ROK could either individually or in collaboration provide technical assistance and training to those countries to which they export nuclear materials, equipment, and technology, and particularly to those developing countries that do not possess a nuclear security infrastructure.

The third step is to promote a security culture and best practices. The nuclear security summits also encouraged countries, regulatory bodies, research and technical support organizations, the nuclear industry, and other relevant stakeholders to help build a "security culture," and share good practices and lessons learned at the national, regional, and international levels. Both countries have programs for providing such assistance, and should emphasize encouraging their nuclear cooperation partners to exchange information and best practices on nuclear security in order to help build an effective security culture in those countries. Industries in both countries should also have programs to further these objectives with states to which they are supplying nuclear materials, equipment, and technology.

The fourth step is to encourage international and regional cooperation in education and training. The summit process also encouraged stronger international and regional cooperation with regard to education, awareness-raising, and training, including through nuclear security centers of excellence. At the 2010 Nuclear Security Summit, China, the ROK, and Japan pledged to create Centers of Excellence (COE) or Nuclear Security Training and Support Centres (NSSCs), whose main purpose would be to train individuals on nuclear security matters—in other words, they focus on the human factor of nuclear security. Japan established a COE in 2010, and the ROK followed in 2014; China will open its facility in 2015. The United States established a collaborative nuclear security center in 2011 with China, with the objective of

enhancing China's domestic nuclear security capabilities and of serving as a regional hub for the dissemination of best practices in the field. The center would provide a resource for sharing technical data and best practices, establishing training programs, "and promoting technical collaborations that will enhance nuclear security in China and throughout Asia."[279] The United States will supply trainers and machinery for the center, while China will bear most of the cost of its operation. The two countries also created a training center in China that would educate customs officials in the detection of trafficked nuclear materials. The ROK and the U.S. should look for opportunities to establish similar cooperative relationships with each other and possibly with their nuclear trading partners.

The COEs/NSSCs could play an important role after the 2016 Nuclear Security Summit in sharing technical data and best practices, establishing training programs, and promoting technical collaboration to enhance nuclear security. The U.S. and the ROK should give careful consideration to how these COEs may be best utilized. Some experts have advocated that COEs should not restrict themselves to the technical aspects of nuclear security, and should integrate policy elements with their technical focus. They should include information-sharing as an important part of improving nuclear security and should go beyond exchanges of materials on laws and regulations. They should also share information on such non-sensitive matters as to whether countries are fully implementing the IAEA's physical protection recommendations, whether they are participating in a peer review process with the IAEA or others, how they have implemented the resulting recommendations, and whether they have completed a comprehensive threat analysis. These experts believe that COEs can play a key role in determining whether the answers to these questions can safely be shared, with whom, and in what form. Another possibility is supplementing the IAEA peer review process with a regional peer review system.[280] The main challenges to COEs/NSSCs will be budgetary, priority, and sustainability.

In 2012, the IAEA established an International Network for Nuclear Security Training and Support Centres (NSSC Network) in order to share lessons learned, and to promote regional and interregional cooperation between such centers. The objectives of the NSSC Network are to promote a high level of nuclear security training and support services, and to facilitate cooperation and assistance activities (including technical and scientific efforts), to optimize the use of available resources, and to leverage these resources to meet specific needs. In February 2013, NSSC members from China, Japan, and the ROK met in Vienna and established the Asia Regional Network under the auspices of the NSSC Network.[281] Membership is open to all IAEA member states, observers to the IAEA, and other relevant stakeholders that are involved, or are planning to be involved, in the provision of training and/or technical and scientific support in the area of nuclear security. Any of these groups can request membership in the IAEA through their official established channels. The U.S. and South Korea should coordinate their efforts to encourage their trading partners to participate in the COEs and the NSSC Network. They should also take steps to ensure that such centers receive sufficient priority and resources to carry out their critical functions.

The fifth step is to promote the security of radiological sources. The 2014 Hague Nuclear Security Summit saw 23 states, including the United States and the ROK, sign a statement in which they agreed to secure dangerous radiological sources that could be used in so-called dirty bombs. The parties to the statement pledged to secure all their most dangerous Category I radiological sources under guidelines set out by the IAEA in its "Code of Conduct on the Safety and Security of Radioactive Sources" by the end of 2016. They "declared their commitment to secure IAEA Category 1 sources consistent with the IAEA's Code of Conduct on the Safety and Security of Radioactive Sources and with consideration of Nuclear Security Series 14: Nuclear security recommendations on radioactive material and associated facilities and Nuclear

Security Series 15: Nuclear security recommendations on nuclear and other radioactive material out of regulatory control."[282] The ROK and the U.S. should take the necessary steps to fulfill these commitments, and should press their cooperating partners to make the same commitments.

The sixth step is to reinforce the central role of the IAEA. There will be a clear need for continuing high-level attention to nuclear security cooperation after the nuclear security summit process comes to an end in 2016. All three nuclear summits confirmed the central role of the IAEA in strengthening the international nuclear security framework, and the Agency is likely to be a central focus for promoting nuclear security following the end of the summits. The IAEA has an extensive program devoted to nuclear security enhancement, and it provides guidance, information, training, and assistance to help member states enhance their nuclear security practices, including a Trafficking Database Program, Integrated Nuclear Security Support Plans, and numerous training and education programs.[283] States participating in the summit process pledged to work to ensure that the IAEA continues to have the appropriate structure, resources, and expertise needed to support the implementation of nuclear security objectives. The U.S. and the ROK should encourage their nuclear trade partners to participate in these various programs, if they do not already do so, and to participate in Agency meetings, working groups, and support other programs on nuclear security. They should also redouble their efforts to support the IAEA's security role. The IAEA continues to rely heavily on extrabudgetary contributions for these programs. The U.S. and the ROK should press for increasing the funds in the regular IAEA budget devoted to nuclear security and to increase their voluntary contributions to this program. They should encourage their nuclear trade partners to do the same.

Nongovernmental Organizations

The World Institute for Nuclear Security (WINS) is a nongovernmental organization that provides a forum for sharing best practices in strengthening the physical protection and security of nuclear and radioactive materials and facilities worldwide. WINS brings together nuclear security experts, the nuclear industry, governments, academia, and international organizations to focus on improving security at nuclear facilities around the world. It has developed numerous best practice guides on a wide range of nuclear security topics. The WINS Academy is a new, online certification course that offers a core curriculum and electives in different professional areas. The U.S. and the ROK governments and industry should encourage their nuclear trading partners to take advantage of these programs.

The Role of Industry

This chapter has stressed the important roles that the private nuclear industries of both the U.S. and the ROK can play in advancing the two nations' nonproliferation, safety, and security agendas. KEPCO and Westinghouse are two of 11 global reactor suppliers[284] that have adopted the so-called Nuclear Power Plant and Reactor Exporters' Principles of Conduct.[285] Sponsored by the Carnegie Endowment for International Peace and adopted on September 15, 2011, the principles set standards of practice for companies across the range of issues examined in this chapter, including safety, liability insurance, security, and nonproliferation, as well as environmental protection, spent fuel management, and ethics. They reflect the participating companies' commitment to their customers to develop and share best practices that reinforce and enhance existing codes, standards, and regulations in all these areas. The companies meet regularly to update each other on their implementation efforts and discuss best practices, engage stakeholders, and update the principles.

At their meeting in Seoul in October 2014, the vendors underscored the importance of the integrity of the supply chain to the safety of the nuclear power plants they export, and discussed the importance of deeper engagement with suppliers, in particular in their quality assurance programs. American and South Korean nuclear reactor vendors should work together to encourage countries receiving nuclear assistance from them to have their companies, whether public or private, adopt these same principles. In addition, Westinghouse and KEPCO should also work to extend these principles to cover their entire nuclear supply chains by encouraging their suppliers to adopt the same codes of conduct in nonproliferation, safety, and security. The nuclear industry associations in both countries, such as the Nuclear Energy Institute in the United States and the Korea Nuclear Association and the Korea Atomic Industry Forum, could also implement programs to educate American and Korean nuclear firms on the importance of instituting internal compliance programs and, where appropriate, of providing advice and assistance to their foreign customers on nuclear exports, nuclear safety, and nuclear security.

CHAPTER 8

Summary and Conclusions

This report has sought to assess the prospects for enhanced collaboration between the Republic of Korea and the United States in fostering the civil uses of nuclear energy in third countries while ensuring the highest standards of nuclear nonproliferation, security, and safety. The two countries already enjoy a strong relationship in bilateral peaceful nuclear trade and in cooperation in nuclear ventures in third counties, such as the United Arab Emirates and China, as well as in various bilateral and international nuclear R&D projects. They also work closely in promoting nonproliferation, nuclear security, and safety objectives. The conclusion of a new ROK-U.S. civil nuclear cooperation agreement and the projected growth in nuclear power worldwide offer new opportunities for deepening and expanding U.S.-ROK collaboration in promoting these objectives in third countries.

U.S. Laws and Policies: Their Relevance for U.S.-ROK Collaboration

Because the participation of American industry in the global nuclear market is governed by a range of laws, regulations, and policies, this report has described in some detail how these apply to various kinds of U.S. nuclear exports, and has explored their implications for U.S.–South Korean nuclear cooperation. The Atomic Energy Act is the primary legal instrument governing U.S. nuclear exports, and peaceful nuclear cooperation agreements (so-called 123 agreements) provide the basic legal framework for U.S. nuclear exports. Such agreements contain strict nonproliferation conditions, including guarantees and assurances by cooperating partners of peaceful, non-explosive use, the application of IAEA safeguards in perpetuity, and consent rights over reprocessing, retransfer, enrichment and storage of plutonium and HEU.

A peaceful nuclear cooperation agreement, however, is legally required for the transfer of only a few items—nuclear materials, nuclear facilities, and their major components and equipment. Peaceful nuclear cooperation agreements are not needed for the transfer of other nuclear items, substances, and technology. Their exporting is governed by different legal instruments and assurances between the U.S. and its cooperating partner. But even for those exports that do not require a peaceful nuclear cooperation agreement, one of the key factors that the U.S. takes into account in approving such transfers is whether the U.S. has such an agreement in effect with the destination state.

Perhaps the most relevant and important U.S. legal requirement for American-Korean nuclear collaboration in the global nuclear market is article 57.b of the AEA and its implementing regulation—part 810 of the *Code of Federal Regulations*—because they apply to South Korean reexports of U.S. reactor and other nuclear technology to third countries. The export of nuclear technology may be approved under an agreement for cooperation, but technology exports can also be authorized by

the secretary of energy under the part 810 regulation—and virtually all U.S. nuclear technology exports have been authorized using the part 810 option. Most nuclear technology exports to South Korea are authorized on a general basis and do not require a special authorization from the secretary of energy.

However, under the current part 810 regulation, a special authorization of the secretary of energy is required for the transfer of technology to a list of 76 countries. Therefore, if the ROK were to wish to reexport U.S.-origin nuclear technology to any of these countries, the retransfer would require the special authorization of the secretary of energy. The vast majority of these countries are not likely candidates for nuclear cooperation with the ROK or the U.S. They include states that are not parties to the NPT, are non–nuclear weapon states that do not have comprehensive safeguards agreements, do not share U.S. nonproliferation objectives, or are developing nations with no nuclear programs. The list contains three countries with major nuclear programs—China, Russia, and India. Even though these three countries have agreements with the U.S., transfers and retransfers of nuclear technology to these states would require special authorization of the secretary of energy.

DOE is presently proposing changes to the part 810 regulation that, among other things, would increase the number of countries for which specific authorizations are required from 76 to 146. General authorization would apply to those countries that have an agreement for cooperation with the United States, with the exception of China, India, and Russia. The revision would add Kazakhstan, Ukraine, the United Arab Emirates, and Vietnam to the generally authorized list of countries.

The Strictness of U.S. Laws and Policies and Its Effect on U.S. Competitiveness in the International Market

A major issue is whether and to what extent the comparatively rigorous U.S. nuclear export control system could lead potential customers to turn away from cooperation with the U.S. and the ROK and toward other nuclear suppliers, or motivate South Korean companies to decline to collaborate with U.S. nuclear firms because they believe tough U.S. nonproliferation policies would hurt ROK prospects with third-party customers.

In the 1970s and 1980s, the United States imposed nonproliferation conditions that most other nuclear suppliers did not, for example, by (1) requiring comprehensive safeguards as a condition of supply to non–nuclear weapon states, (2) imposing broad and restrictive consent rights over enrichment and reprocessing of U.S.-obligated nuclear material, (3) restraining the transfer of sensitive nuclear technology, and (4) imposing export controls on nuclear dual-use items and technology. In some cases, these disparities clearly hurt American competitiveness in the international nuclear market. U.S. nuclear cooperation was cut off from a number of states, and other suppliers took the place of American companies. For example, during the later 1970s, the United States strongly opposed reprocessing and the civil use of plutonium in all countries, and sought to use its prior consent rights to promote that objective. The resulting delays and uncertainties in U.S. approval of requests for reprocessing and retransfers for reprocessing led some foreign utilities to turn to non-U.S. sources for their uranium enrichment services and also for other nuclear supplies.

Over time, however, the disparities between U.S. nuclear export controls and those of other major supplier states have greatly diminished**.** The bilateral controls of each individual supplier state were eventually supplemented by two internationally coordinated nuclear export control regimes—the Zangger Committee and the Nuclear Suppliers Group. Today, the conditions of supply set out in the NSG guidelines are broadly similar to U.S. nuclear export controls. Still, the multinational systems are voluntary, and variations therefore exist among individual suppliers in their policies and practices and in their interpretation of the

international guidelines. In many cases, however, these differences should have little or no practical effect on the competitive position of the United States in the global market.

Nonetheless, despite much greater harmonization between the nuclear export policies and practices of the United States and those of other suppliers, differences continue to exist. Some of these have been cited as hurting U.S. competitiveness. These include:

- The United States' reputation, gained largely in the 1970s, as an unreliable and unpredictable cooperating partner, particularly in the exercise of its consent rights. This includes the legally mandated character and the greater strictness and breadth of U.S. consent rights compared with those of other suppliers.
- The slowness and inefficiency of the U.S. export approval process, particularly the handling of requests for technology exports and reexports.
- Potential changes to the AEA.

Reputation and consent rights. In the 1980s and 1990s, the U.S. went to some lengths to reestablish its reputation as a reliable supplier by giving advance consent to reprocessing and enrichment for its cooperating partners that already had such capabilities, were close allies, had excellent nonproliferation credentials—for example, Japan and Euratom—and were located in areas of little proliferation concern.

In addition, the more extensive and stricter U.S. consent rights on reprocessing, the storage of weapon-usable materials, and enrichment may not have as much adverse effect on consumers' willingness to cooperate with the U.S. as they had in the past, for three reasons: (1) only a few countries have enrichment and reprocessing facilities, (2) newly emerging nuclear programs in the developing world have demonstrated little interest in acquiring such capabilities, and (3) the economic and fuel supply and fuel management cases for such fuel cycle facilities has not been proven, especially in countries with small nuclear programs.

The U.S. has also shown a willingness to give advance consent for retransferring nonsensitive materials, equipment, and components to third countries with which the U.S. has an agreement for cooperation—for example, the U.S. gave such consent to Euratom. It has also given advance approval in some cases—for example, the UAE and Taiwan—to transfer U.S.-obligated spent fuel to Euratom for reprocessing, which would reduce the perceived need to reprocess indigenously. Hence, it is not at all clear that U.S. consent rights are likely to be a major impediment to the United States' competitiveness in the international market.

Policy on technology exports and the inefficiencies of the approval process. The U.S. industry regards the requirements for specific authorizations for technology transfers and retransfers contained in the part 810 regulation as an impediment to American competitiveness, and has registered concerns about the regulation's overly broad scope, lack of clarity and predictability, and outdated provisions, and also the protracted period required by DOE to process applications for specific authorization.

Interviews by the authors of this report with U.S. industry sources revealed complaints that the part 810 approval process is so onerous and time-consuming that some U.S. firms have lost out on foreign sales. South Korean industry representatives have also complained to the authors that the U.S. is slow in approving requests for reexports of technology. In 2010 the Government Accountability Office issued a report that, in many respects, reiterated these concerns and highlighted the slowness and inefficiencies of the part 810 process.

Notwithstanding the widespread dissatisfaction with the part 810 approval process, it has apparently not caused great harm to U.S. nuclear exports

to South Korea or ROK retransfers of U.S.-origin technology to third countries. DOE is in the process of updating its part 810 regulations, which will hopefully respond to most of industry's concerns, while at the same time protecting U.S. national security interests. Whether the new regulations will achieve these objectives remains to be seen.

Changes to the Atomic Energy Act. The House Foreign Affairs Committee unanimously adopted a bill in 2012 that would require that all future U.S. peaceful nuclear cooperation agreements contain a legal commitment by the cooperating partner to abstain from acquiring enrichment or reprocessing capabilities, with the stipulation that any agreement submitted to Congress without this provision would require an affirmative vote of the two houses of Congress. The committee reintroduced the same bill in 2013, but it has not passed either house of Congress.

The administration decided to adopt a case-by-case approach toward this issue, whereby the U.S. would press future partners, except for the ROK and the IAEA, to make a legal undertaking to refrain from enrichment and reprocessing, but would not necessarily walk away from an agreement if the other country refused to accept this condition. The U.S. required such a commitment in its recently concluded agreement with Taiwan, but sought a compromise formula in its agreement with Vietnam. That agreement contains no legally binding commitment on enrichment and reprocessing. Rather, in the agreement's preamble, Vietnam affirmed its intent "to rely on existing international markets for fuel services rather than acquiring sensitive nuclear technologies." At the same time, the U.S. is insisting on a legally binding pledge of no enrichment and reprocessing from countries in regions of instability or proliferation concern, such as the Middle East.

Despite the case-by-case approach that the U.S. administration has adopted, many in Congress and the U.S. nonproliferation community remain committed to enacting legislation that would require a pledge of no enrichment and no reprocessing in all future U.S. agreements. There may be special cases where such a pledge would be appropriate, for example, regions of instability and of proliferation concern. In addition, some potential partners will have political and strategic reasons for concluding a peaceful nuclear cooperation agreement with the United States, and may well be willing to provide some form of commitment to abstain from enrichment and reprocessing, especially if they envision having little practical nuclear energy need to acquire fuel cycle capabilities in the foreseeable future.

However, adopting such a requirement for all future nuclear cooperation agreements would seriously threaten the prospects for concluding new agreements because most countries regard access to such technology as their right under the NPT. Moreover, any attempt by the U.S. to impose this requirement could lead many states to find other suppliers that do not require a similar pledge as a condition for their nuclear trade.

Despite the various criticisms of U.S. nuclear export laws and policies, the degree to which comparatively strict U.S. nuclear export controls affect U.S. competitiveness in the global market is difficult to pin down. A 2010 study by the Government Accountability Office identified several other factors that impede the ability of the U.S. industry to compete globally for nuclear trade, including a decline in domestic manufacturing capabilities, the U.S. industry's liability concerns, and the emergence of other suppliers that place great emphasis on supporting bids through high-level government advocacy and strong financial support. Moreover, other factors may favor the United States over its international competitors, including the close political and strategic relationship that the U.S. enjoys with a number of countries, the quality of its advanced nuclear technology, and its excellent safety standards.

Although the U.S. may have stricter nonproliferation requirements than many other suppliers,

this difference has not prevented the U.S. from concluding agreements with 19 individual countries, Taiwan, and two international organizations, including Euratom and its 28 member states. Finally, precisely because of the strict nature of U.S. nonproliferation requirements, some countries are interested in concluding peaceful nuclear cooperation agreements with the United States because they view the United States' willingness to conclude such agreements as a validation of their nuclear nonproliferation credentials.

Potential Markets

Seoul is interested in competing for nuclear projects in a number of countries, including China, India, Vietnam, Indonesia, Poland, Jordan, Saudi Arabia, Turkey, and South Africa.

China is planning on a major expansion of its nuclear power program, and is basing its technology development for the immediate future on the Westinghouse AP1400 reactor. South Korea is playing an important role in Westinghouse's sales to China. South Korea's Doosan Heavy Industries & Construction has partnered with Westinghouse to supply two pressure vessels and four steam generators for the two AP1000 nuclear power reactors it is constructing in China. South Korea hopes that the contract with Westinghouse will be a stepping stone for South Korean companies to expand in the nuclear power market in China and other countries. However, China wants to become progressively more self-sufficient in deploying AP1000s and its own derivatives, and is placing emphasis on using domestic products in the key equipment and components of nuclear reactors. Whether and to what extent Doosan or other South Korean companies will be able to participate in future Chinese nuclear projects may depend on whether China has the domestic capacity to meet its ambitious nuclear power goals and to what extent it may have to resort to foreign companies to fill the gaps. The continuation of South Korea's cooperation with Westinghouse in the Chinese nuclear program will depend heavily on the renewal of the U.S.-China cooperation agreement, the proposed text of which is expected to be submitted to Congress in early 2015.

India is also a potential market for South Korean nuclear exports, but the ROK is behind its competitors, particularly Russia and France. Moscow seems to be the main partner of choice for New Delhi. In December 2014, Russia signed a strategic vision document on nuclear power with India that said both sides would strive to complete the construction and commissioning of "not less than 12 units" in the next two decades. The South Koreans are now waiting for the Indian government to allot a site for a nuclear reactor. However, the initiation of peaceful nuclear trade with India faces several obstacles, particularly if it involves the retransfer of U.S. nuclear technology from the ROK to India. First, many potential nuclear suppliers, including the United States, will not export to India because New Delhi's 2010 law on civil liability for nuclear damage provides that operators of nuclear plants can hold foreign suppliers liable in the event of an incident due to faulty equipment or material supplied. Second, Japan and India have been unable to conclude an agreement due to differences with regard to nonproliferation. The absence of an Indian-Japanese nuclear pact could block the supply of U.S. reactor vendors—Westinghouse-Toshiba and GE-Hitachi—as well as a range of other global nuclear reactor manufacturers, because the reactor pressure vessels for many reactors are made by the Japanese heavy forging firm Japan Steel Works. Without an agreement, Japan will not permit nuclear exports to India.

Finally, New Delhi has refused to provide the U.S. with information that tracks and accounts for material subject to the U.S.-Indian agreement or to permit end-use monitoring of certain exports—which is not only a common practice among nuclear trading partners but also a requirement of the U.S. legislation that authorized the initiation of U.S.-Indian peaceful nuclear cooperation. Until all of these issues are resolved, both U.S. nuclear exports to India and South Korean nuclear trade

with that country that is tied to U.S. export controls will be problematic.

Vietnam is purchasing its first reactors from Russia and Japan. The U.S. has recently concluded an agreement for peaceful nuclear cooperation with Vietnam that could facilitate American–South Korean nuclear collaboration with that country and, in particular, the retransfer of U.S.-origin technology from South Korea to Vietnam for its third nuclear project.

Indonesia, Malaysia, and the Philippines are also potential markets for South Korean nuclear exports, but these countries have not committed to initiating a nuclear program. Of these countries, the U.S. has agreements in effect only with Indonesia.

The European countries—particularly *Romania, Poland, and the Czech Republic*—are also potential markets for South Korean nuclear exports. However, the ROK appears to be in an uphill battle—behind France, Russia, and China—to win reactor contracts with these countries. The U.S. has a peaceful nuclear cooperation agreement with Euratom that would facilitate U.S.–South Korean collaboration in the event South Korea were to win bids for reactors in these countries.

In *the Middle East*, the ROK is interested in selling its reactor technology to *Jordan, Saudi Arabia, and Egypt*, and it has already signed an agreement with Jordan for a research reactor. However, funding is very important for Jordan's ability to build a power reactor, and Amman seems to be favoring Moscow to build its first nuclear reactor due to the strong financial support that Moscow is prepared to provide. Saudi Arabia has signed agreements with a number of potential suppliers but has not yet committed to initiating a nuclear program.

The U.S. has not concluded an agreement for cooperation with either Jordan or Saudi Arabia because of these countries' reluctance to agree to the United States' demand that they forswear the acquisition of enrichment and reprocessing. The U.S. has an agreement for cooperation with Egypt, but Russia appears to be the clear partner of choice to develop Egypt's first nuclear power plant. Russia's willingness to finance Egyptian reactors is clearly a key factor in that choice.

Turkey will purchase its first nuclear plant from Russia, with French participation, and its second from a Japanese-French consortium. In 2014 Westinghouse, China's State Nuclear Power Technology Corporation, and Electricity Generation Company (the largest electric power company in Turkey) announced an agreement to enter into exclusive negotiations to develop and construct a four-unit nuclear power plant site in Turkey based on the AP1000 reactor's technology.

South Korea made a proposal to sell a reactor to Turkey, but it foundered over a dispute regarding electricity sales guarantees. The United States has a peaceful nuclear cooperation agreement in effect with Turkey that would facilitate the retransfer of U.S.-origin technology to Turkey, if Ankara decides to purchase Seoul's reactors.

In *South Africa*, South Korea faces aggressive competition from France, especially Russia, and possibly China in trying to sell its nuclear reactor technology to that country.

Some of the countries that South Korea is targeting for its nuclear exports are in the early stages of planning nuclear power programs, whereas others are more advanced. Given the poor financial condition of some of these countries and their lack of any kind of nuclear infrastructure, it is far from certain that the ambitious nuclear power programs of many of them will be realized.

Moreover, in pursuing their nuclear exporting goals, South Korea and the United States face competition from traditional suppliers, such as France and Russia, and also new suppliers, such as China and Japan. Through its aggressive nuclear export promotion policies, Moscow is winning

competitions by offering below-market financing, and providing a complete range of products and services, including manufactured parts, engineering services, construction, operations, maintenance, and fuel. In countries with little or no domestic nuclear infrastructure or experience, including Turkey and Vietnam, Russia has offered a full build-own-operate model. Russia has also agreed to take back the spent fuel produced from the fuel it supplies—a strong selling point that neither the ROK nor the U.S. is able to offer.

Although China is facing strains in its capacity to meet its ambitious domestic construction goals, Beijing is aiming to sell nuclear technology in the global market. China is also pursuing aggressive financing tactics, as is evidenced by its willingness to invest in the reactors it is proposing to build in Romania. Beijing is also teaming its firms up with Westinghouse to compete in the international market.

Potential Cooperation between the United States and South Korea

This report has sought to identify the overall comparative advantages and disadvantages of the American and South Korean nuclear industries, recognizing that such relative strengths and weaknesses could in certain cases promote collaboration in some markets, while giving one country or the other an edge in competing for sales in other cases.

The U.S. nuclear industry has important strengths in such areas as advanced reactor designs, excellence in nuclear safety, the provision of a full range of nuclear services, including engineering and construction, nuclear fuel services, and the manufacturing of high-precision components, as well as a proven record in working with partners around the world on technology transfer, localization, education and training, high standards for quality assurance, and a demonstrated ability to build plants internationally. On the other hand, the nuclear industry in the United States suffers from a number of significant weaknesses, including the failure to build a nuclear plant in 40 years, the atrophying of U.S. manufacturing capability, and inadequate high-level political support from the U.S. government for the country's nuclear exports.

Of particular significance is the uncertain and weak nature of U.S. government financial support for nuclear exports. The U.S. Ex-Im Bank has been the subject of considerable controversy in Congress, and its charter has been extended only to June 30, 2015. This contrasts with the particularly aggressive financing terms that Russia employs to increase its share of the global nuclear energy market. The failure of adequate financial support may be particularly damaging to the prospects for U.S. nuclear exports in developing countries that are undertaking new nuclear programs. Another factor that puts the U.S. industry at a disadvantage is the growing trend among suppliers toward investment in plants they sell abroad. Most importing countries, especially developing economies, want co-investment as part of any deal to purchase foreign nuclear technology. Although U.S. firms are taking some investment positions in foreign reactor projects, this approach has its limits because U.S. companies simply do not have the requisite finances to invest heavily in such projects.

The South Korean nuclear industry also has its strengths and weaknesses. The ROK's nuclear industry is well integrated. It is able to quote an accurate total price because key subcontractors are part of its one, cohesive team. In contrast, Westinghouse does not have such an integrated team. It must assemble a group of subcontractors and cannot be certain about a total project price. Westinghouse is also not a construction company, and this is a disadvantage compared with the integrated South Korean team.

The South Korean nuclear industry has also has a number of other strengths: a good track record for construction, operation, and maintenance; a consistent government policy; strong nuclear infrastructure; on-time performance with good

scheduling software; and a well-integrated industry with robust supply chains—engineering, construction, fuel, and competitive pricing with continuous production.

In addition, the ROK government's ownership of KEPCO presents a major competitive advantage for South Korean companies compared with those in the U.S. industry. Indeed, the highly coordinated support the South Korean nuclear industry receives from the ROK government is an important factor bolstering South Korea's position in the global nuclear market.

On the other hand, the South Korean nuclear program suffers from some limitations and weaknesses that could adversely affect its competitiveness, including limited experience in the international nuclear market compared with its larger competitors, and several domestic scandals that have damaged its reputation.

The comparative strengths and weaknesses of the U.S. and South Korean nuclear industries may favor one or the other when they are in direct competition for markets in third countries. For example, the strong political and financial support that South Korea's government gives to the country's companies; the country's proven record of building reactors at a low cost and on schedule; and Korea's ability to provide major component parts that the U.S. no longer manufactures put the ROK in a strong position to compete not only with the United States but also with other suppliers. Conversely, the advanced reactor technology offered by the United States, America's high safety standards, and the United States' strong political, economic, and strategic relationship with a number of countries could provide important advantages for U.S. firms. In some markets, each industry may see benefits in going at it alone as much as possible or in teaming up with other partners, such as Westinghouse and China in Turkey.

In other cases, the two nations' industries may complement each other and favor collaboration in joint projects in the global market. The U.S. and South Korean nuclear industries are natural partners in several areas—with common technology, a minimal language barrier, and a long-standing familiarity between the two industries, especially between KEPCO and Westinghouse. Both industries use the same codes and standards of the American Society of Mechanical Engineers, and the ROK has adopted the NRC's licensing practices and has introduced the Bechtel system of engineering. Project implementation is similar in both countries. Such commonalities should ease cooperation between the U.S. and ROK industries.

In addition, the relative strengths of one may compensate for the weaknesses of the other. For example, the ROK is especially strong in its manufacturing capabilities of major components; the integrated nature of its industry; its good track record for construction, operation, and maintenance; the consistency of its government policy; its strong nuclear infrastructure; and the financial and political support it receives from the ROK government. These advantages may compensate for the sharp decline in some U.S. manufacturing capabilities. On the other hand, U.S. strengths in safety may help compensate for the reputational damage that the ROK industry has recently suffered in that area. American strengths in such areas as advanced reactor designs, the provision of high-precision products, and a proven record in constructing reactors in the global market could complement the ROK's capabilities. In addition, the political, economic, technical, and strategic relationship that the two countries enjoy with each other may prove advantageous to winning contracts in some countries.

One model for possible U.S.-ROK collaboration is the UAE project, where the ROK and the U.S. initially competed. Then the winner, the ROK, took on the U.S. to provide a wide range of support for the project, including design, technical support services, consulting on licensing issues, control equipment, and instrumentation and major components, as well as engineering, construction

management, training, legal, regulatory, environmental, and other services. The model of the UAE deal is likely to be replicated in the next two reactors to be built in the UAE.

Another model could be the development at the outset of a joint proposal by U.S. and South Korean companies, such as Westinghouse and KEPCO, in bidding for reactors in third countries. A joint proposal might make sense if one party decided that it did not want to compete for a particular project on its own, if it knew that there was little chance of winning the bid independently, or if the two parties concluded that a joint proposal might give them a comparative advantage vis-à-vis competitors. Such U.S.–South Korean collaboration may prove one of the few ways to compete against the aggressive export policies of other suppliers, including Russia.

Westinghouse has adopted this model in its proposed collaboration with China's State Nuclear Power Technology Corporation for the development and construction of a four-unit plant for Turkey's state-owned Electricity Generation Company. China intends to become a major exporter, and Westinghouse's work with Chinese companies in constructing power reactors in China creates natural opportunities for Westinghouse-Chinese cooperation on joint export projects—a development that could be in direct competition with South Korean nuclear exports.

One important reason for close collaboration between the U.S. and South Korea is strategic. Both U.S. and South Korean nuclear industries will face fierce competition from Russia, which has many advantages in exporting its nuclear technology—its vertically integrated industry, strong support from government, aggressive financing, and spent fuel take-back policy. China is also likely to be a major force in the international market in the longer term. A strengthened U.S.–South Korean alliance to compete in the international civil nuclear marketplace thus could offer a major counterbalance to Russian and Chinese influence in this key strategic area.

The Potential Role of the U.S. Government in Promoting U.S.-ROK Collaboration

The U.S. government can play a role in facilitating both South Korean nuclear exports to third countries and U.S.-ROK cooperation in the global market by (1) replacing existing bilateral U.S. peaceful nuclear cooperation agreements and concluding agreements with new partners; (2) facilitating approvals for the retransfer of U.S.-origin nuclear materials, equipment, and components from the ROK to third countries; (3) putting its own nuclear export house in order; and (4) expanding U.S.-ROK intergovernmental R&D cooperation.

New and replacement agreements. The United States presently has 19 peaceful nuclear cooperation agreements in force with individual countries, as well as with Taiwan, the IAEA, and Euratom with its 28 member states. Most of the countries in which South Korea has shown interest in selling its nuclear products and services have agreements with the United States, the major exceptions being Jordan, Saudi Arabia, and the Philippines.

The U.S. peaceful nuclear cooperation agreement with China will expire in December 2015, and its replacement will be particularly important not only to avoid a cutoff of U.S. nuclear exports to China but also to enable continued U.S.-ROK collaboration in nuclear projects in China. The replacement agreement, which is expected to be submitted to Congress soon, may prove contentious, given Beijing's nuclear exports to Pakistan in violation of the NSG guidelines, its human rights record, and its provocative actions in the South China Sea and East China Sea over disputed claims to islands there. On the other hand, the prospect that China will purchase eight new Westinghouse reactors will create strong commercial incentives for approval of the replacement agreement.

Negotiating new U.S. peaceful nuclear cooperation agreements with countries in the Middle East,

such as Jordan and Saudi Arabia, may present major challenges. Some in the U.S. have expressed concerns that introducing nuclear power into this highly unstable region would not be in the national security interest of the United States. At the very least, the U.S. government would regard it as vitally important that any new civil nuclear programs introduced into the region not include enrichment or reprocessing capabilities. Moreover, it is highly doubtful that Congress would approve any agreement with a Middle Eastern country that did not contain some form of commitment to abstain from acquiring enrichment or reprocessing capabilities.

Jordan has publicly rejected the U.S. request to forswear these technologies. In addition, the Jordanian government has recently confirmed that it has concluded an agreement with Russia's Rosatom to build the nation's first nuclear plant under very favorable financial terms. Concluding a U.S.–Saudi Arabian peaceful nuclear cooperation agreement will face two potentially critical and interrelated political obstacles. The first is a concern that an Iranian nuclear program and Israel's presumed nuclear arsenal might force Saudi Arabia to follow suit. The second is U.S. insistence on obtaining a Saudi legal commitment to forswear indigenous enrichment and reprocessing capabilities. Whether Riyadh would be willing to go along with such a demand remains to be seen. In any event, any U.S.-Saudi agreement is likely to be highly controversial in the U.S. Congress.

The absence of a U.S. peaceful nuclear cooperation agreement with these countries could adversely affect South Korean–U.S. collaboration in these markets. The U.S. could not export nuclear materials and reactors or their major components to these countries, nor permit the retransferring of such items from the ROK to these states. The absence of an agreement would also make it more difficult for the U.S. to approve the nuclear exports or reexports of other nuclear components or items to these countries, even though they do not require such an agreement. In addition, the export or retransfer of technology to a country without an agreement would not be generally authorized and would require a specific authorization from the secretary of energy.

Facilitating reexports. In addition to replacing expiring agreements for cooperation and negotiating new ones with countries that the ROK sees as potential customers for its nuclear exports, the U.S. can take steps to facilitate retransfers of U.S.-origin nuclear materials, equipment, components, and other substances to such countries by giving the ROK advance consent to retransfer items and material to a list of specified countries, thus avoiding a requirement for case-by-case approvals of retransfers. This could include advance approval to transfer U.S.-obligated spent fuel to Euratom for reprocessing to relieve South Korea of some of its pressing spent fuel storage problems.

Improving the export approval process and export performance. The U.S. could help facilitate South Korean retransfers of U.S.-origin technology by reforming its part 810 regulations so that they are clearer and by expediting the approval process. In addition, various organizations have made numerous recommendations for improving U.S. export performance, including increasing the role of the Export-Import Bank in supporting U.S. nuclear exports, promoting the nuclear industry in the U.S., and allocating funding and resources for promoting commercial nuclear export opportunities.

Expanding R&D cooperation. The U.S. and the ROK are already cooperating in R&D in areas such as pyroprocessing, spent fuel management, and fast reactors. The U.S. has so-called action plans and MOUs with several countries that facilitate R&D collaboration in key facilities and technologies unique to each party. The ROK and the United States might find it useful to enhance and broaden their cooperation through the establishment of similar relationships with DOE. Strengthened R&D cooperation between the U.S. and the ROK could lead to the development and commercialization of new technologies that could in turn

strengthen the competitiveness of both countries in the global market and enhance prospects for collaboration in third countries' nuclear programs.

ROK-U.S. Cooperation in Advancing Nuclear Nonproliferation, Security, and Safety Objectives

Effective nuclear export controls exercised by individual governments, along with other elements of the nonproliferation and nuclear security and safety systems, are necessary to provide the public and national governments with confidence that the proliferation and safety risks associated with civil nuclear energy are manageable. The ROK and U.S. governments, as well as their respective companies, should cooperate to further their mutual nonproliferation, security, and safety objectives. Actions that the two countries could take as part of their nuclear cooperation in third countries should include the following.

Nonproliferation:

- Strengthen the IAEA's safeguards system by requiring new cooperating partners to adopt the Additional Protocol to their safeguards agreements with the IAEA, which provides the Agency with additional information on and access to their peaceful nuclear activities.
- Provide assistance to customer states embarking on nuclear programs to establish an effective system of nuclear materials protection, accounting, and control.
- Assist the authorities in third countries to develop the capacity and procedures to cooperate in the interdiction of items of proliferation concern that may be transiting or originating from their territories.
- Provide technical and/or financial assistance to help other states to implement their obligations to establish and implement effective export controls under UN Security Council Resolution 1540. They should also share information with each other and with their cooperating partners about clandestine procurement efforts by countries of proliferation concern.
- South Korea should consider including requirements for ROK consent to reprocessing and enrichment in all new nuclear cooperation agreements, and particularly in any agreements with developing countries or regions of proliferation concern, in order to help prevent the spread of sensitive nuclear technologies.
- South Korea should also increase its resources and capacities in nonproliferation and export control.

In areas of political instability or high proliferation risk, the U.S. and South Korea should coordinate their civil nuclear cooperation policies closely to ensure that these countries do not acquire enrichment or reprocessing capabilities.

Safety:

The U.S. and the ROK should work together to encourage countries engaged in nuclear cooperation with them to:

- Have their companies, whether public or private, adopt the "Nuclear Power Plant and Reactor Exporters' Principles of Conduct."
- Establish a strong, financially and politically independent nuclear regulatory system.
- Ratify and implement the Convention on Nuclear Safety and make public annual national reports under the convention.
- Ratify the Conventions on Assistance in Case of a Nuclear Accident and Early Notification of a Nuclear Accident.
- Invite peer reviews of safety planning, and conduct regular performance testing of nuclear safety and disaster management preparations.

- Establish cooperative relationships with the IAEA's Department of Nuclear Safety and Security, and invite operational safety review teams to help provide relevant advice and assistance on nuclear safety matters.

Nuclear liability:

- Both states should promote the adoption by cooperating states of the Convention on Supplementary Compensation for Nuclear Damage.

Nuclear security:

The U.S. and South Korea should press their nuclear cooperating partners to carry out steps to strengthen nuclear security that were called for at the nuclear summits in Washington, Seoul, and The Hague. In particular, they should:

- Require that their future cooperating partners adhere to the Convention on the Physical Protection of Nuclear Material (CPPNM) and ratify its 2005 amendment, and encourage all states to become party to the ICSANT. Seoul has ratified the CPPNM and ICSANT. To be credible, Washington needs to take immediate steps to ratify the CPPNM and the ICSANT.
- Require or at least encourage future cooperating states to incorporate the IAEA's physical protection guidelines into their national laws and regulations, conduct self-assessments of their nuclear security systems, host periodic peer reviews by the IAEA International Physical Protection Advisory Service (IPPAS missions), and implement recommendations identified in the reviews. They should also provide cooperating partners with technical and financial assistance to further their nuclear security policies and practices in coordination with the IAEA.
- Consider incorporating provisions into their bilateral cooperation agreements that would establish mechanisms to build an effective security culture in those countries that are party to the agreements.
- Consider establishing a joint ROK-U.S. collaborative nuclear security center—or perhaps expand South Korea's center of excellence called the International Nuclear Security Academy (INSA)—to serve as a resource for sharing technical data and best practices, and for establishing training programs.

ENDNOTES

1. The International Atomic Energy Agency (IAEA) has recently projected that overall nuclear generating capacity will grow by between 17 and 94 percent by 2030 depending on a wide range of factors, such as global economic growth. The International Energy Agency, in the 2014 edition of its *World Energy Outlook*, projects global nuclear power capacity to increase by almost 60 percent in its central scenario, from 392 GW in 2013 to more than 620 GW in 2040. China accounts for 45 percent, while India, the Republic of Korea (ROK), and Russia collectively make up a further 30 percent of this projected growth. International Energy Agency, *World Energy Outlook* (Paris: International Energy Agency, 2014), available at http://www.worldenergyoutlook.org/.
2. Peaceful nuclear cooperation agreements are often referred to as "123 agreements" because they are governed largely but not exclusively by section 123 of the U.S. Atomic Energy Act.
3. This practice is supported by section 402 of the U.S. Atomic Energy Act, which prohibits the exporting of source material for the purposes of enrichment except pursuant to an agreement for cooperation.
4. The so-called Schumer Amendment to the U.S. Energy Policy Act (1992) required foreign reactors supplied with highly enriched uranium (HEU) fuel by the United States to commit to converting to operate on LEU fuel as quickly as possible and prohibited exports of HEU to foreign reactors if they did not undertake such obligations. The implementation of this amendment, in combination with LEU fuel development and a drop in the construction of new reactors, facilitated a rapid decline in U.S. HEU exports. On July 29, 2005, Congress passed the Energy Policy Act of 2005, which included provisions relaxing restrictions on HEU exports for medical isotope production. The new law permits the export of U.S. HEU to medical isotope producers even if they refuse to convert to LEU. In recent years, there have been only a handful of HEU exports for that purpose. In 2012, the United States announced a number of measures to encourage reliable supplies of molybdenum-99 (MO-99) produced without HEU, including steps to further reduce exports of HEU for medical isotope production when sufficient supplies of non-HEU-produced MO-99 are available to the global marketplace. In January 2013, the president signed into law the Medical Isotope Production Act. Among other things, the law directs the secretary of energy to establish a technology-neutral, cost-shared program to evaluate and support projects for the domestic production of MO-99 for medical uses without the use of HEU and prohibits the NRC from issuing a license for the export of HEU for medical isotope production effective seven years after the date of enactment.
5. U.S. law does not ban the export of plutonium, but the United States as a matter of policy does not export plutonium. However, the United States has given consent to the use of plutonium recovered from United States–obligated spent fuel in the civil nuclear programs of Euratom, India, Japan, and Switzerland.
6. The United States does not export heavy water reactors and does not presently have the capability to produce reactor pressure vessels.
7. For the definition of these various terms, see U.S. Nuclear Regulatory Commission, "Part 50: Domestic Licensing of Production and Utilization Facilities," http://www.nrc.gov/reading-rm/doc-collections/cfr/part050/full-text.html.
8. The U.S. Atomic Energy Act defines the term "restricted data" as meaning all data concern-

ing (1) design, manufacture, or utilization of atomic weapons; (2) the production of special nuclear material; or (3) the use of special nuclear material in the production of energy, but shall not include data declassified or removed from the Restricted Data category by the proper authority.

9. This does not include plutonium contained in spent fuel.
10. The term "sensitive nuclear technology" means any information (including information incorporated in a production or utilization facility or important component part thereof) that is not available to the public and that is important to the design, construction, fabrication, operation, or maintenance of a uranium enrichment or nuclear fuel reprocessing facility or a facility for the production of heavy water, but shall not include Restricted Data.
11. Section 130.g. (2) of the Atomic Energy Act stipulates that "[F]or purposes of this section insofar as it applies to section 123 . . . continuity of session is broken only by an adjournment of Congress sine die; and . . . the days on which either House is not in session because of an adjournment of more than three days are excluded in the computation of any period of time in which Congress is in continuous session." The effect of this provision is that (1) any period of continuous session terminates only with the final adjournment of the last session of a Congress; but (2) in determining the length of a period of continuous session, any day on which *either* house is in a recess of its session is not counted. This arrangement is apparently intended to prevent a situation in which an agreement would go into effect only because Congress was not in session, or did not remain in session long enough to act on a disapproval resolution.
12. However, this provision of the law also allows the president to waive this requirement and to permit nuclear exports if he determines that a cessation of nuclear cooperation would be prejudicial to the achievement of U.S. nonproliferation objectives or otherwise jeopardize the common defense and security of the United States.
13. However, before the effective date of any such determination, the president must submit the determination, together with a report containing the reasons for his determination, to the committee on international relations of the House of Representatives and the committee on foreign relations of the Senate for a period of 60 days of continuous session. (The president actually waived this requirement for the United States–India peaceful nuclear cooperation since India had detonated a nuclear device after entry into force of the NNPA.) 22 U.S. Code 8003. Waiver authority and congressional approval, http://www.law.cornell.edu.uscode/text/22/8003. The Henry Hyde Act on the U.S.-India Nuclear Cooperation Act also exempted India from the comprehensive safeguards requirement. Henry J. Hyde United States–India Peaceful Atomic Energy Cooperation Act of 2006 HR 5682.
14. Pursuant to sections 4 and 6 of the Taiwan Relations Act, PL 96-8, 93 Stat. 14, and Executive Order 13014, 61 FR 42963, any international agreement entered into by the United States and the governing authorities on Taiwan before January 1, 1979, and in force between then on December 31, 1978, is administered on a nongovernmental basis by the American Institute in Taiwan, a nonprofit District of Columbia corporation, until the agreement's termination.
15. The conditions in sections 127 and 128 are the same as those specified in sections 123 for agreements for cooperation.
16. Section 126 a. (1)
17. See "Part 110: Export and Import of Nuclear Equipment and Material," http://www.nrc.gov/reading-rm/doc-collections/cfr/part110/.
18. Jonathan B. Schwartz, "Controlling Nuclear Proliferation Legal Strategies of the United States," *Law and Policy in International Business* 20, no. 1 (1988).

19. "Electronic Code of Federal Regulations," http://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title10/10cfr810_main_02.tpl.
20. Aside from the U.S.-Australian agreement on SILEX, the only exception has been the approval of the transfer of pyroprocessing technology to the ROK in connection with the Joint Fuel Cycle Study being conducted by authorized technical experts from the United States and the ROK. The purpose of the Joint Fuel Cycle Study is to explore the technical and economic feasibility and the nonproliferation acceptability of the electrochemical recycling process and of other spent fuel management options. (The U.S. government has concluded that electrochemical recycling technology, as defined in the agreement, is sensitive nuclear technology within the meaning of U.S. law.)
21. DOE is proposing changes to its regulations that would make exports and re-ports to the UAE and Vietnam generally authorized.
22. This treaty provides that Latin American is a nuclear-weapon-free zone.
23. 10 CFR part 810,10
24. For the proposed changes to Part 810, see http://nnsa.energy.gov/sites/default/files/nnsa/07-13-inlinefiles/2013-07-31%20SNOPR.pdf.
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27. The Export Administration Act Regulations Part 772.2 states that, "knowledge of a circumstance (the term may be a variant, such as 'know,' 'reason to know,' or 'reason to believe') includes not only positive knowledge that the circumstance exists or is substantially certain to occur, but also an awareness of a high probability of its existence or future occurrence. Such awareness is inferred from evidence of the conscious disregard of facts known to a person and is also inferred from a person's willful avoidance of facts."
28. Export Administration Regulations Part 744.2, http://www.ecfr.gov/cgi-bin/text-idx-?SID=ec6b6559d58e6f63f05ff50eea2e44a4&node=se15.2.744_12&rgn=div8.
29. Proposed Agreement between the United States and Japan Concerning Peaceful Uses of Nuclear Energy, Message from the President of the United States (Washington: U.S. Government Printing Office, 1987), 369.
30. Dual-use items are those that may be used for both nuclear and nonnuclear uses.
31. The current members of the Zangger Committee are Argentina, Australia, Austria, Belgium, Bulgaria, Canada, China, Croatia, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, the Republic of Korea, Luxemburg, the Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Turkey, Ukraine, the United Kingdom, and the United States. The European Commission is a permanent observer. Current members of the NSG are Argentina, Australia, Austria, Belarus, Belgium, Brazil, Bulgaria, Canada, China, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Kazakhstan, the Republic of Korea, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Turkey, Ukraine, the United Kingdom, and the United States. In addition, non-NSG members, such as India and Israel, have indicated that they would abide by the guidelines of the NSG. India is presently applying for membership in the NSG.
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http://www.vertic.org/media/assets/nim_docs/NSG%20and%20ZC/infcirc209r2m1.pdf. For the latest edition of the NSG guidelines covering nuclear exports, see INFCIRC/254/REV.12 / Part 1, http://www.nei.org/Master-Document-Folder/Backgrounders/White-Papers/Nuclear-Export-Controls-A-Comparative-Analysis-of. For the latest edition of the NSG guidelines for dual-use items, see INFCIRC/254/Part2/Rev.9/, http://www.iaea.org/Publications/Documents/Infcircs/2013/infcirc254r9p2.pdf.

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166. U.S. utilities will find it difficult to justify the investment of large amounts of capital in SMRs that might not pay back for a decade or longer; reducing the size of the reactor means a loss of economies of scale and having more units increases the chance that a safety problem could emerge at one of them: the power output of some SMRs is so low per unit that 10s of them would be needed to make the equivalent power output of one advanced light water reactors; the efficiency of SMRs in converting thermal energy into electrical output tends to be lower than current light water reactors; and the regulatory structure is not favorable for small reactors. NRC regulations for control-room staff levels, emergency planning zones and security are all predicated on large, above-ground reactors and may have to be modified to address the specific characteristics of small reactors.
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177. A company with an "N" stamp means it has received nuclear accreditation from the American Society of Mechanical Engineers and that has produced nuclear-grade components in accordance with the society's Boiler and Pressure Vessel Nuclear Codes and standards; see http://neinuclearnotes.blogspot.com/2006/04/n-stamp-of-approval.html.
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191. Marvin Fertel, "Testimony before the House Committee on Financial Services," June 25, 2014, http://www.nei.org/CorporateSite/media/filefolder/Policy/Trade/Testimony-HFSCExIm.pdf?ext=.pdf.
192. Caroline Reda, "Why the Export-Import Bank?" *Star News Media*, August 14, 2014, http://www.starnewsonline.com/article/20140814/ARTICLES/140819854.
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194. This information is from CINTAC; see "Civil Nuclear Trade Advisory Committee (CINTAC)," http://trade.gov/mas/ian/nuclear/tg_ian_003233.asp.
195. Government Accountability Office, "Government-wide Strategy Could Help Increase Commercial Benefits from U.S. Nuclear Cooperation Agreements with Other Countries," November 2010.
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ROK are expected to witness a rapid increase in nuclear equipment manufacturing capabilities and emerge as significant contributors to global nuclear construction. According to the report, the industrial capacity of suppliers in the nuclear sector has decreased in the last 20 years, leading to fewer reactor designs, skilled employees, and project management organizations from which to choose. Currently, nuclear system suppliers are based in the United States, Russia, the ROK, Japan, India, France, China, and Canada. The localization of skills and capabilities in China, India, and the ROK is expected to enhance the nuclear capabilities of these countries.

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216. "Maintaining U.S. Leadership in Global Nuclear Energy Markets: A Report of the Bipartisan Policy Center's Nuclear Initiative," September 2012.
217. "KEPCO to support US licensing of APR1400," *Nuclear Engineering International,* September 16, 2014.
218. Ibid.
219. Kane and Pomper, "Reactor Race."
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222. In 1992, when the NSG adopted the guideline that called for comprehensive safeguards for nuclear exports to non–nuclear weapon states, it applied only to subsequent nuclear cooperation and did not cover supply commitments that existed at the time; this provision is known as the "grandfather clause." In a formal "declaration of existing projects" made at the time it joined the NSG in 2004, Beijing informed the NSG of its 1991 cooperation agreement with Pakistan, under which it had supplied a 300-megawatt reactor at Chashma and had just undertaken to supply an additional 325-megawatt reactor at the same location. The Chinese claimed that the supply of these reactors did not constitute a "new" supply commitment and therefore was grandfathered under the NSG comprehensive safeguards guideline. This was a dubious claim at the time because the

1991 Chinese-Pakistani pact was a general framework agreement and reportedly did not contain an actual commitment to supply reactors at Chashma. In any event, Beijing's 2004 explanations to the NSG did not mention grandfathering any more reactors under the 1991 agreement. Since then China has supplied additional nuclear plants at the Chashma site that are not be covered by the 1991 agreement, are not being grandfathered under the NSG guidelines, and clearly violate the commitments China made when joining the NSG in 2004.

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236. "Saudis May Go Nuclear." Also see Bipartisan Policy Center, "Maintaining U.S. Leadership in Global Nuclear Markets," September 2012; "U.S. Domestic Civil Nuclear Infrastructure"; "Restoring U.S. Leadership in Global Nuclear Energy: A National Security Imperative," Center for Strategic and International Studies, June 2013, http://csis.org/publication/restoring-us-leadership-nuclear-energy.
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for nuclear energy, U.S. Department Energy, before the Subcommittee on Energy and Water Development and Related Agencies, Committee on Appropriations, U.S. House of Representatives, March 14, 2013.

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250. Such collaboration is called for in UN Security Council Resolution 1540, which calls on states to put in place "appropriate effective measures to account for and secure" WMD-related items in production, use, storage, or transport and to "maintain appropriate effective physical protection measures" of said items. Although the resolution is aimed primarily at nonstate actors, it obliges states to put in place export controls. It also calls upon "all States to . . . develop appropriate ways to work with and inform industry and the public regarding their obligations under such laws."
251. A good illustration of the problem is the case of a firm in Malaysia that participated in the Khan network by making thousands of high-precision aluminum centrifuge parts, including the casings and molecular pumps that were being shipped to Libya when they were found on the ship MV BBC China in October 2003. When the Government of Malaysia released a public report of its police investigation into the company's activities and the Khan network, it concluded that the NPT does not control centrifuge components because they are not listed in the NPT. As one observer has pointed out, "No participant in the Zangger Committee could plausibly argue that centrifuge components do not constitute 'especially prepared or designed equipment,' as stated in article III, paragraph 2, of the NPT." See Jacob Blackford, "Multilateral Nuclear Export Controls after the A. Q. Khan Network," Institute for Science and International Security, January 13, 2005, updated August 2, 2005.
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253. For a current assessment of the implementation of UNSC Resolution 1540, see Igor Khripunov, "A Work in Progress: UN Security Resolution 1540 after 10 Years," *Arms Control Today*, May 2014, http://www.armscontrol.org/print/6250.
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and Control," http://www.kinac.re.kr:8181/eng_images/activ/kinac_en.pdf; Korea Institute for Nuclear Nonproliferation and Control, "2013 Strategic Implementation Report."

255. Whether to ask such countries to join the Zangger Committee or the NSG or simply adhere to their guidelines depends on many factors. Enlarging the membership of the multilateral regimes, particularly the NSG, will only make it more difficult for them to function efficiently and effectively. Adding new states with divergent interests may make it more difficult to maintain effective nuclear export standards or to upgrade those standards when circumstances dictate. Conversely, excluding any state that has the potential to cause damage to the nonproliferation regime may mean that such a state will not adhere to responsible export policies. Such states have little incentive to adhere to the guidelines if they are not permitted to participate in the decisions of the groups. See Jacob Blackford, "Multilateral Nuclear Export Controls after the A. Q. Khan Network," Institute for Science and International Security, January 13, 2005 (updated August 2, 2005); and Harald Müller, "The Future of Export Controls in International Nuclear Non-Proliferation," paper presented at International Seminar on the Role of Export Controls in Nuclear Non-Proliferation, October 1997.
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their safeguards agreement with the IAEA in effect. The exceptions are Argentina, Brazil, and Egypt, which have neither signed nor ratified the AP.

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263. The guidelines provide that pending the entry into force of an AP, suppliers may authorize transfers only when the recipient "is implementing appropriate safeguards agreements in cooperation with the IAEA, including a regional accounting and control arrangement for nuclear materials, as approved by the IAEA Board of Governors." This loophole covers Argentina and Brazil by virtue of the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials (ABACC) which is responsible for the application of the Agreement for Exclusively Peaceful Uses of Atomic Energy, signed by Brazil and Argentina, and to coordinate Argentina-Brazil-IAEA-ABACC Quadripartite Agreement. However, the authorities of the ABACC and that safeguards agreement are by no means equivalent to the authorities of the IAEA under the AP, which is precisely the reason Argentina and Brazil object to the AP—it would give more authority to the IAEA than to their own inspectors.
264. Hans Blix, "Keynote Speech," session 1 of International Seminar on the Role of Export Controls in the Nuclear Non-Proliferation Regime, 1997.
265. International Institute for Strategic Studies, "Nuclear Black Markets: Pakistan, A. Q. Khan and the Rise of Proliferation Networks," May 2007; Ian Anthony, Christer Ahlström, and Vitaly Fedchenko, Reforming Nuclear Export Controls: The Future of the Nuclear Suppliers Group, *SIPRI Research Report 22* (Oxford: Oxford University Press for Stockholm International Peace Research Institute, 2007), http://books.sipri.org/files/RR/SIPRIRR22.pdf.
266. Anthony, Ahlström, and Fedchenko, "Reforming Nuclear Export Controls." These denials include decisions not to act on an export application, rather than an official denial of the application.
267. IAEA, *Report of the Commission*.
268. Ibid., annex, 22.
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270. "Strengthening the Effectiveness and Improving the Efficiency of Agency of Agency Safeguards, Report by the Director General," GC (58)/16, IAEA, August 15, 2014.
271. Meeyoung Cho, "South Korea Suggests Northeast Asia Nuclear Safety Group," *Reuters*, August 15, 2014, http://www.reuters.com/article/2014/08/15/us-nuclear-safety-southkorea-idUSKBN0GF0A920140815.
272. "Foreign Ministry to Host a Symposium on Nuclear Safety in Northeast Asia (2nd TRM+)," Press Release, ROK Ministry of Foreign Affairs, November 25, 2014, http://www.mofat.go.kr/ENG/press/pressreleases/index.jsp?menu=m_10_20&sp=/webmodule/htsboard/template/read/engreadboard.jsp%3FtypeID=12%26boardid=302%26seqno=314570.
273. "Liability for Nuclear Damage," World Nuclear Association, updated September 2014.
274. Ibid.
275. The convention applies only to international transportation. The 2005 amendment is an important one because it extends the convention's provisions to domestic activities.
276. The nuclear security fundamentals specify the objective of a state's nuclear security regime and the essential elements of such a regime and provide the basis for the IAEA's Nuclear Security Recommendations that

set out measures that states should take to achieve and maintain an effective national nuclear security regime consistent with the fundamentals.

277. The secretary of energy, Ernest Moniz, announced that the United States has recently hosted an IPPAS mission at the National Institute of Standards and Technology's Center for Neutron Research—a Category 1 site in the United States. At the request of the Government of the ROK, the IAEA conducted a two-week IPPAS mission that reviewed the nation's nuclear security-related legislative and regulatory framework for nuclear and other radioactive material and associated facilities, as well as security arrangements applied to the transportation of nuclear material and radioactive sources, and to computer systems. In addition, the team reviewed physical protection systems at the Hanbit Nuclear Power Plant, operated by KHNP, and at the High-Flux Advanced Neutron Application Reactor, operated by KAERI.
278. IAEA, *Nuclear Security Report 2014* (Vienna: IAEA, 2014).
279. "U.S., China Sign Agreement to Establish Center of Excellence on Nuclear Security," http://nnsa.energy.gov/mediaroom/pressreleases/chinacenterofexcellence01.19.11
280. Kenneth Williams and Sarah Williams, "Integrating Nuclear Security and Policy: Asian Nuclear Security Centers," Center for Strategic and International Studies, July 2014.
281. Bonnie Jenkins, "IAEA International Network for Nuclear Security Training and Support Centers," July 18, 2014, http://csis.org/files/attachments/140718_CoEWorkshop_Jenkins_IAEANSSC.pdf.
282. The IAEA's Code of Conduct on the Safety and Security of Radioactive Sources is a nonbinding international legal instrument that provides guidance for ensuring the control of radioactive sources and for mitigating/minimizing any consequences if control measures fail. Also legally nonbinding, the supplementary guidance on the import and export of radioactive sources was developed in 2004 to support states' implementation of the code. According the IAEA's *Nuclear Security Report 2014*, as of June 30, 2014, 122 states had informed the IAEA's director general of their intention to implement the Code of Conduct, and 89 states of their intention to implement the supplementary guidance.
283. These are designed to assist member states in applying a structured and holistic approach to nuclear security capacity building as well as for enabling increased coordination between the IAEA, the state concerned, and potential donors.
284. They have been adopted by nine companies, based in Canada, France, Japan, Russia, South Korea, and the United States. AREVA, ATMEA (an AREVA-Mitsubishi joint venture), Atomstroyexport, Candu Energy (the successor exporting company to Atomic Energy of Canada Limited), GE Hitachi Nuclear Energy, Hitachi-GE Nuclear Energy, Korea Electric Power Company (KEPCO), Mitsubishi Heavy Industries (including Mitsubishi Nuclear Energy Systems, a subsidiary), Toshiba, and Westinghouse Electric Company.
285. "Nuclear Power Plant and Reactor Exporters' Principles of Conduct," http://nuclearprinciples.org/about/about-the-principles-of-conduct/.

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