South Korea’s Nuclear Dilemmas
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ABSTRACT
Since the beginning of 2018, the nuclear dynamics surrounding the Korean Peninsula have started to change rapidly and dramatically. The world is now watching a series of historic negotiations in which the denuclearization of the Korean Peninsula is to be discussed. Meanwhile, South Korea’s current nuclear policies look paradoxical, mainly in two ways. First, although the Moon Jae-in administration is adhering to its nuclear phaseout policy, the country’s nuclear capacity is likely to grow during his term. Second, South Korea is continuing its research on pyroprocessing – which can be controversial especially from a nonproliferation perspective – for its future spent fuel management while at the same time pursuing the denuclearization of the Korean Peninsula. This article describes the country’s current nuclear capacity, reviews the history of spent fuel management in South Korea, discusses differing views of nuclear elites and the Korean public on the nuclear phaseout and back-end fuel cycle policies, and explains how these paradoxes in current nuclear policies have emerged. The article concludes that South Korea faces nuclear policy dilemmas and that the current policy incoherence could worsen in the future because of contentious internal dynamics.

Introduction
The Moon Jae-in administration’s stance on nuclear issues seems to be ambivalent and confusing not only to its domestic electorate but also to its international audience. During his presidential campaign, Moon pledged to phase out nuclear energy due to growing public concerns about safety of the country’s nuclear facilities. South Korean citizens’ anxieties about nuclear safety have certainly increased over the past years, especially after the 2011 accident at the Fukushima Daiichi Nuclear Power Plant in Japan, which included nuclear core meltdowns caused by the unprecedented earthquake and tsunami, and the 2015 earthquake in Gyeongju. That South Korean city is host to a repository for the disposal of low- and intermediate-level radioactive waste and is close to other host cities for nuclear power plants such as Ulsan and Busan. After taking office, President Moon reaffirmed his pledge to make South Korea a nuclear-free country in his speech on 19 June 2017, at the ceremony marking the shutdown of Kori 1, South Korea’s first commercial nuclear reactor, which had been in operation since 1978. On the other
hand, he also announced the resumption of the construction of Shin Kori 5 and 6. During his presidential campaign, Moon had pledged to stop the construction of Shin Kori 5 and 6. The construction had been temporarily halted since mid-July 2017, while the Public Deliberation Committee on Shin Kori Nuclear Reactors No. 5 and 6 discussed the issue. On 20 October 2017, the committee concluded that about 60% of the participants in the final survey were in favor of resuming the construction work, and Moon accepted the decision (World Nuclear News 2017). Nevertheless, on 22 October 2017, President Moon reiterated that the government will continue to phase out nuclear-generated electricity (Jang 2017).

Regarding the back end of the fuel cycle, during his presidential campaign, Moon had promised to reconsider research on pyroprocessing technology (Kim 2017); that research is conducted by the Korea Atomic Energy Research Institute (KAERI) in order to produce fuel for fast-neutron reactors jointly with the United States. Almost a year after Moon’s inauguration, however, the South Korean government decided to continue its financial support for research and development (R&D) on pyroprocessing until 2020 as originally planned (Won 2018).

South Korea’s current nuclear policies look paradoxical mainly in two ways. First, although the Moon Jae-in administration is adhering to its nuclear phaseout policy, the country’s nuclear capacity is likely to grow during his administration, and it is not certain that Moon’s gradual nuclear phaseout will be realized in the coming decades. Second, South Korea keeps working on alternative recycling technology for spent fuel management, namely pyroprocessing – which can be controversial, especially from a nonproliferation perspective – while pursuing the denuclearization of the Korean Peninsula. What do all these mixed messages and decisions mean? This article aims to explain the historical background of South Korea’s nuclear program and to analyze factors behind the current paradoxes of South Korean nuclear policies.

This article is organized in the following way: first, it provides a snapshot of South Korea’s views on its own nuclear armament; it is necessary to understand domestic voices for its nuclear armament, which cannot be completely separated from debates on the nuclear phaseout policy and spent fuel management. Second, it presents an overview of South Korea’s current nuclear capacity and its prospects. Third, it explains the current situation of South Korea’s spent fuel storage and its policies for spent fuel management. Fourth, it provides a historical review of changes in South Korea’s back-end fuel cycle policies. Fifth, it summarizes recent controversies surrounding the nuclear phaseout and pyroprocessing. Finally, it concludes with an analysis of the South Korea’s nuclear dilemmas.

**South Korea’s Views on its Nuclear Armament**

Since the 2018 New Year’s Address delivered by North Korean leader Kim Jong-un, the dynamics surrounding the Korean Peninsula have started to change very rapidly and dramatically. Three inter-Korean summits have been held between April and September 2018, and the first, historic summit between the United States and North Korea was held in Singapore in June 2018. President Donald Trump and Chairman Kim Jong-un exchanged several letters to reconfirm their commitment to the negotiations for the denuclearization of the Korean Peninsula. Though the
negotiations seem to be slow in progress, it would be fair to say that the rest of the world saw some hopes for a more peaceful, nuclear-weapon-free peninsula in the developments of 2018.

These changes were not even imaginable in the previous year. Throughout 2017, the tension over North Korea’s nuclear program had continued to escalate. When North Korea conducted its sixth nuclear test, on September 6, nuclear armament of South Korea reemerged as a topic among Korean media and was publicly discussed. Hard-line politicians, including the leadership of the Liberty Korea Party (LKP), have called for the nation to acquire nuclear weapons to balance against those of the Kim Jong-un regime. Also, the leadership of LKP insisted on redeployment of US tactical nuclear weapons to the country. Since 1958, the United States had deployed tactical nuclear weapons in South Korea until 1991 when the last US nuclear weapons were withdrawn from the country (Kristensen and Norris 2017).

Voices for nuclear armament have been rising in South Korea over the past few decades. Whenever there have been nuclear tests by North Korea, some segments of the South Korean public demanded that South Korea should develop its own nuclear weapons or bring back tactical nuclear weapons from the United States. About two out of three South Koreans seemed to support nuclear weapons for their country in a September 2017 public poll right after North Korea’s sixth nuclear test (Lee 2017b). Politicians and pundits also have argued that South Korea should be allowed to reprocess spent fuel for plutonium, as Japan does. This would put South Korea in a position to produce nuclear weapons more quickly (Kang 2016). According to Hwang Il-soon, a professor emeritus of nuclear engineering at Seoul National University (SNU), South Korea needs to have a reprocessing plant to produce weaponizable plutonium, with which it would need just one year to produce enough weapons-grade plutonium to fuel roughly 20 warheads (Oswald 2018). Yim Man-sung, another well-known nuclear engineer at the Korea Advanced Institute of Science and Technology (KAIST), estimates the country needs two years for technical development of a nuclear weapon, setting aside all political difficulties (Oswald 2018). Suh Kune-yul, a professor of nuclear engineering at SNU, said that “if we (South Korea) decide to stand on our own feet and put our resources together, we can build nuclear weapons in six months. The question is whether the president has the political will” (Sanger, Choe, and Rich 2017). In 2015, Charles Ferguson, then president of the Federation of American Scientists, said that South Korea had up to 4330 bombs’ worth of plutonium at the Wolsong site, assuming a conservative estimate of about 6 kg plutonium for a first-generation fission device. The CANDU (CANadian Deuterium Uranium) spent fuel stored at Wolsong at the time contained about 26,000 kg of plutonium (Ferguson 2015).

Especially since North Korea’s sixth nuclear test, on 6 September 2017, there have been renewed voices from influential politicians calling for South Korea to acquire nuclear weapons to deter the North from using its nuclear weapons against the South. Most of these politicians are from right-leaning parties that are currently in the opposition. Hong Joon-pyo, who was the leader of the major conservative party, the LKP, also has been calling for the return of US tactical nuclear weapons to South Korean territory to balance North Korea’s nuclear-weapon capability. Hong
said that, if the US government declines to bring back the weapons, South Korea should pursue nuclear armament by itself (Song 2017). After extensive interviews with a wide range of prominent South Korean leaders, Einhorn and Kim (2016) described the motivations for the expressions of support for nuclear weapons as follows:

- **Seeking more credible deterrence.** At the core of many pro-nuclear voices are doubts about the US nuclear umbrella.
- **Correcting asymmetry.** For some South Koreans, an indigenous nuclear capability would serve the important political purpose of correcting a critical asymmetry between North Korea and South Korea, an asymmetry that places Seoul in a highly disadvantageous position relative to Pyongyang.
- **Pressuring Beijing and Washington.** For a significant number of South Korean politicians and pundits, expressions of support for the nuclear option do not reflect a genuine interest in pursuing nuclear weapons, but instead are intended to serve a tactical purpose: putting some pressure on China and, to a somewhat lesser extent, the United States to act with greater resolve to achieve the denuclearization of North Korea.
- **Playing to domestic constituents.** In the view of several South Koreans interviewed, the pro-nuclear statements by South Korean politicians have been less a carefully considered assessment of the merits of the issue and more a way of demonstrating resolve to their largely conservative constituents in the face of the growing North Korean challenge.
- **Expressing widespread frustration and fear of abandonment.** Many of the South Koreans surveyed, whether conservative or progressive, offered an additional and more general explanation, not just for the pro-nuclear statements themselves but also for why those statements may strike a sympathetic chord even among many South Koreans who oppose their country’s acquisition of nuclear weapons. In a word, that explanation is “frustration” – mainly frustration at the failure to rein in North Korea’s nuclear and missile capabilities.

President Moon announced at his National Assembly address on 1 November 2017, that South Korea would not seek nuclear weapons and emphasized the goal of a denuclearized Korean Peninsula (Taylor 2017). However, he articulated a different view on nuclear-powered submarines. During his presidential campaign, Moon expressed support for the introduction of nuclear-powered submarines, pledging to make efforts to gain the backing of the United States. Amid North Korea’s evolving nuclear and missile threats, South Korea has started a feasibility study on building a nuclear-powered submarine. The South Korean Navy had commissioned a private institute to find ways to resolve international restrictions on building a nuclear submarine in August 2017 (Yonhap 2017). During the bilateral summit held in Seoul on 8 November 2017, President Moon discussed with President Trump his interest in deploying nuclear-powered submarines to defend against North Korean ballistic-missile submarines, and the two leaders agreed to begin consultations on South Korea’s acquisition and development of cutting-edge weapons including nuclear-powered submarines (Jun 2017; Gady 2017). According to *Defense News*, South Korea’s Navy
considered building a 5000 ton nuclear-powered submarine modeled after the French 5300 ton Barracuda-class submarine (Jeong 2018).

However, as negotiations for the denuclearization of the Korean Peninsula proceeded, the discussion on its own nuclear armament and nuclear-powered submarines gradually lost public attention in South Korea. Of course, nuclear armament needs to be distinguished from nuclear programs for civilian purposes. However, the back end of the fuel cycle is interrelated with the issue of nuclear proliferation. The major aim of this article is to help readers understand paradoxes in South Korea’s nuclear policies, including its development of the back end of the fuel cycle for civilian purposes. Accordingly, in the following sections, the article will focus on situations and issues related to civilian purposes.

South Korea’s Nuclear Power Capacity

As one of the most rapidly growing economies, South Korea has been increasingly relying on nuclear power since 1978, when it started operations at the country’s first commercial nuclear power plant, Kori 1. Currently, South Korea has 24 power reactors in operation, with a total capacity of 22.5 GW electric (GWe): 20 pressurized water reactors (PWRs) and four CANDU heavy-water reactors (HWRs), the latter with a combined capacity of 2.8 GWe. All the nuclear power plants in South Korea are located along the coast of the peninsula, as shown in Figure 1. Kori 1, with
a capacity of 576 megawatts electric (MWe), was permanently shut down in June 2017 after 40 years of its operation. In 2016, electricity generated from nuclear power constituted 29% of South Korea’s total electric power production (162 TWh) (World Nuclear Association (WNA) 2018). Figure 2 shows the past and expected growth in installed nuclear capacity until 2035 before the Moon administration started in May 2017 (Kang 2017).

During his campaign, Moon pledged that he would cancel the deployment of new reactors in South Korea, including Shin Kori 5 and 6, which were less than 30% complete. He also committed to shutting down Wolsong 1, a CANDU HWR that had been allowed a 10-year life extension beyond the 30 years of its initial operating license; banning life extension of all reactors; and achieving a goal of zero nuclear reactors after 40 years of operation (Kim 2017). In June 2018, Korea Hydro & Nuclear Power (KHNP) decided to close Wolsong 1 prior to the expiration of its extended operating license, which was until November 2022 (World Nuclear News 2018).

In response to the strong opposition to his nuclear phaseout policy from the South Korean nuclear establishment, politicians from the opposition parties, and conservative news media, President Moon has changed some of his positions. He said at the shutdown ceremony for Kori 1 that the fate of Shin Kori 5 and 6 would be determined by public consensus as soon as possible (Jang 2017). His administration’s five-year plan, released by a special advisory committee on 19 July 2017, described the government’s nuclear phaseout policy as follows:
Figure 3. Installed nuclear capacity in South Korea based on president Moon’s proposed policies. Source: Calculated by Kang Jung-min in 2017. Provided to the author through a private communication.

Figure 3 shows an updated projection of South Korea’s installed nuclear capacity, based on Moon’s modified nuclear energy policy. Forty-year and 60-year lifetimes have been assumed for the 1 GWe and 1.4 GWe PWRs, respectively, and 40 years and 30 years for the lifetimes of Wolsong 1 and Wolsong 2–4, respectively.

On Shin Kori 5 and 6, however, there was a strong backlash from nuclear power plant builders and local residents who had expected financial benefits from the project. Construction of the two units was halted on 17 July 2017, and the Public Deliberation Committee on Shin Kori Nuclear Reactors No. 5 and 6 was established on 24 July. The committee was chaired by a former Supreme Court justice and had eight members, who are professors and experts from the humanities and sociology, science and technology, statistics, and conflict management. The government excluded people connected with the nuclear and energy sectors. The committee selected a group of ordinary “citizen jurors” to decide whether to stop the construction of Shin Kori 5 and 6 after three months of deliberations. The committee conducted a phone survey of 20,000 participants. From that group, 500 people were selected on September 12 as jurors who would participate in the debates and hearings and would decide the fate of the two Shin Kori units. This type of public deliberative democracy process is unprecedented in South Korea. Out of the 500 citizens, 471, ranging from those in their 20s to senior citizens, held a three-day marathon discussion between 13 and 15 October. On 20 October, the committee finally concluded that the construction of Shin Kori 5 and 6 should be resumed, but in the long term, nuclear power generation should be scaled back in South Korea.
Korea, which is compatible with the Moon administration’s goal of phaseout by 2080. According to the final survey conducted among the participants, 53.2% of them want to reduce nuclear power in South Korea and less than 10% want an expansion (Roh 2017).

Following the recommendation of the committee, on 22 October 2017, President Moon announced the resumption of the construction of Shin Kori 5 and 6 (Jang 2017). Tables 1 and 2 show nuclear power reactors in operation and under construction in South Korea.

### South Korea’s Policies for Spent Fuel Management

At its 253rd meeting in 2004, Korea Atomic Energy Commission (KAEC) announced that a national policy for spent fuel management would be decided later in consideration of progress in domestic and international technology development, and that spent fuel would be stored at reactor sites through 2016 under the authority of KHNP (Korea Atomic Energy Commission (KAEC) 2004).
Since then, South Korea did not update its spent fuel management policy until 25 May 2016, when the South Korean government announced a new national plan on spent fuel management, based on recommendations by the Public Engagement Commission on Spent Nuclear Fuel Management (PECOS), an independent advisory body that was established in October 2013. The main elements of the national plan are as follows:

- The government plans to build a deep geologic disposal repository that is to be operational in 2053. The government is to select a site for an underground research laboratory at the disposal site by 2028, construct it, and do studies there till 2042.
- An interim storage facility to store spent fuel until operation of the repository is to be built at the site by 2035. If necessary, spent fuel would be stored at onsite temporary storage facilities until the interim storage site begins operations. In addition, the government would try to utilize an international spent fuel management facility for storage and disposition of spent fuel if available.
- R&D of reduction of volume and radiotoxicity of spent fuel would be continued (KAEC 2016).

The Moon administration, however, pledged during the campaign to review the previous government’s national plan on spent fuel management in 2018 (Jo 2017). Table 3 shows the spent fuel inventories, spent fuel storage capacities, and anticipated years when the pools at each site will be full as of the end of September 2018. As of December 2018, there is no concrete progress in implementing the policy recommendations above suggested by PECOS.

**History of Back-End Fuel Cycle Policies**

**Reprocessing Programs in the 1970s**

From the beginning of its nuclear power program in the 1970s, South Korea has been intermittently interested in reprocessing spent fuel. Initially, the interest in reprocessing was sparked by the general worldwide enthusiasm for plutonium breeder reactors, and then soon afterwards by consideration of reprocessing as a potential route to a nuclear-weapon program. The South Korean government, when it started its nuclear power program in the late 1960s, shared the great optimism of the global nuclear industry. By the end of the 1970s, South Korea had one PWR (Kori 1) in operation.

In the 1970s, South Korea began to think about plutonium recycling. Its 1968 long-term nuclear plan called for feasibility studies on nuclear fuel fabrication and reprocessing to be completed by 1976. The plan projected that a reprocessing plant would be built by 1981, based on the then-widespread concern among the world nuclear establishment that world uranium reserves would soon be depleted and on the assumption that commercialization of fast breeder reactors would be realized in the 1990s. KAERI called for the construction of a pilot reprocessing plant – 32 metric tons of heavy metal (tHM) in spent fuel per year – by 1976 (Kang and Feiveson 2001).

However, international circumstances altered South Korea’s original plan. In 1970, the United States announced plans to withdraw part of its forces stationed in South Korea, based on the so-called Nixon Doctrine that brought the era of détente. The doctrine originates from then-US President Richard Nixon’s press conference in Guam on...
25 July 1969, which was articulated in his later speech on Vietnamization on 3 November 1969. Since the Nixon Doctrine was announced, the United States tried to reduce the number of its troops deployed abroad. Following this announcement, the United States withdrew some 20,000 of its troops from the 7th Division in 1971. Reduction of the US troops from South Korea was a political shock as well as a huge security challenge to South Korea. Park Jung-hee’s Blue House (Korean Presidential Office) started a secret nuclear-weapon program for national security while US military engagement with South Korea declined during the détente era.

Importing reprocessing technology from France was part of the project. On 19 October 1974, the nuclear cooperation agreement between South Korea and France went into effect, and the South Korean government sought to purchase a pilot reprocessing plant from France. In 1975, the French government notified the South Korean government of its readiness to provide the plant. However, under strong pressure from the United States, the South Korean government ended negotiations in January 1976. KAERI also began negotiations with Canada in 1973 for purchase of an NRX (National Research Experimental) research reactor and with Belgium after 1975 for purchase of a mixed-oxide (MOX) fuel fabrication facility. However, after the explosion in April 1974 of an Indian nuclear device using plutonium produced in the Canadian-provided CIRUS (Canada India Reactor Utility Services) research reactor, a clone of the NRX, the

Table 3. Inventory of spent fuel, spent fuel storage capacity, and anticipated saturation years in South Korea (as of the end of September 2018).

| Reactor          | Type     | Cumulated volume (bundles) | Storage capacity (bundles) | Anticipated saturation year at the site |
|------------------|----------|----------------------------|---------------------------|----------------------------------------|
| Kori 1 (closed)  | PWR      | 485                        | 562                       | 2024                                   |
| Kori 2<sup>b</sup> | PWR      | 724                        | 799                       |                                        |
| Kori 3           | PWR      | 1980                       | 2103                      |                                        |
| Kori 4           | PWR      | 1997                       | 2105                      |                                        |
| Shin Kori 1      | PWR      | 495                        | 1273                      |                                        |
| Shin Kori 2      | PWR      | 590                        | 1273                      |                                        |
| Shin Kori 3      | PWR      | 100                        | 780                       |                                        |
| Hanbit 1         | PWR      | 1648                       | 2105                      | 2024                                   |
| Hanbit 2         | PWR      | 1274                       | 2100                      |                                        |
| Hanbit 3         | PWR      | 911                        | 1125                      |                                        |
| Hanbit 4         | PWR      | 914                        | 1125                      |                                        |
| Hanbit 5         | PWR      | 712                        | 1281                      |                                        |
| Hanbit 6         | PWR      | 713                        | 1281                      |                                        |
| Hanul 1          | PWR      | 864                        | 957                       | 2037                                   |
| Hanul 2          | PWR      | 884                        | 905                       |                                        |
| Hanul 3          | PWR      | 1136                       | 1321                      |                                        |
| Hanul 4          | PWR      | 1090                       | 1321                      |                                        |
| Hanul 5          | PWR      | 893                        | 1281                      |                                        |
| Hanul 6          | PWR      | 664                        | 1281                      |                                        |
| Shin Wolsong 1   | PWR      | 262                        | 523                       | 2038                                   |
| Shin Wolsong 2   | PWR      | 124                        | 523                       |                                        |
| Wolsong 1 (closed) | PHWR    | 28,840                     | 42,408                    | 2019                                   |
| Wolsong 2        | PHWR     | 31,432                     | 42,408                    |                                        |
| Wolsong 3        | PHWR     | 34,440                     | 42,408                    |                                        |
| Wolsong 4        | PHWR     | 36,848                     | 42,408                    |                                        |
| Dry storage      |          | 313,200                    | 330,000                   |                                        |

<sup>a</sup>One bundle of spent fuel is under reburning in the core.

<sup>b</sup>Breakdown of Kori 2: Storage amount in the second quarter (668 bundles) + output in the third quarter (57 bundles) = 724 bundles in storage + 1 bundle in reburning.

Source: Korea Hydro & Nuclear Power’s Homepage.
Canadian government halted negotiations with South Korea. The negotiations with Belgium were ended in November 1977 due to US intervention. The clandestine nuclear-weapon program ended after the assassination of Park in October 1979 (Kang and Feiveson 2001).

Reprocessing Programs in the 1980s and Other Undeclared Experiments

In 1983, KAERI undertook a joint study with Atomic Energy of Canada Limited (AECL) of a “Tandem fuel cycle”, in which spent PWR fuel would be fabricated into fuel for CANDU reactors. In the Tandem fuel cycle, the spent PWR fuel is dissolved, as in conventional reprocessing, but the plutonium and uranium are co-precipitated without separation, while the fission products and higher actinides are removed. The US government opposed the joint study, however, and it ended in late 1983 (Kang and Feiveson 2001).

In July 1981, KAERI irradiated a five-pin miniature fuel assembly, containing 2.5 kg of depleted uranium, for 82 days in the Triga III reactor in Seoul. The mini-assembly was then dismantled and dissolved in a hot cell at the site. In April and May 1982, a small group of KAERI researchers separated tiny amounts (said to be 40 mg or less) of plutonium from the solution of plutonium and uranium fission products. The South Korean government did not report the plutonium separation to the International Atomic Energy Agency (IAEA) (Kang et al. 2005).

In August 2004, the South Korean government publicly revealed that KAERI had secretly conducted the plutonium separation in 1982, conducted chemical uranium enrichment experiments from 1979 to 1981, manufactured depleted-uranium munitions from 1983 to 1987, and experimented with laser uranium enrichment in 2000. By not declaring any of these activities to the IAEA, it was revealed that South Korea had violated its Nuclear Nonproliferation Treaty safeguards agreement (Kang et al. 2005). In November 2004, IAEA Director-General Mohamed ElBaradei reported South Korea’s failure to notify the agency of past research and called South Korea’s failure “a matter of serious concern” (Kerr 2004).

Reprocessing Programs During the 1990s

By the late 1980s, South Korea’s interest in reprocessing remained but focused on the prospect that plutonium recycling could reduce dependence on imported uranium. While energy security remained as a major concern in the 1990s, reprocessing also came to be seen by some in the South Korean government as a solution for South Korea’s spent fuel disposal problem.

In 1991, KAERI and AECL, with the participation of US national laboratories, undertook a feasibility study of the DUPIC (Direct Use of Pressurized Water Reactor Spent Fuel in CANDU) fuel cycle to improve uranium utilization and to reduce spent fuel volume. The basic idea of the DUPIC fuel cycle, like the Tandem fuel cycle, is to refabricate PWR spent fuel, which still contains approximately twice the fissile-material content of natural uranium as well as nonvolatile fission products and higher actinides, into fuel for HWRs, without separating plutonium from either the uranium or non-reactive fission products. In 1999, South Korea set up facilities at the KAERI site for
dismantling small amounts of PWR spent fuel in hot cells at the Post-Irradiation Examination Facility and for fabricating DUPIC fuel bundles. KAERI manufactured DUPIC fuel pellets and pins and tested them in its Hanaro research reactor in 2000. Even though KAERI favored the DUPIC fuel cycle, the Korea Electric Power Corporation (KEPCO) showed no interest in commercialization of the DUPIC fuel cycle due to several factors, including uncertain economics and some technical issues that remained unresolved, especially radiation protection for workers while they are loading DUPIC fuel into existing CANDU reactors (Kang and Feiveson 2001).

Meanwhile, in 1992, South Korea and North Korea agreed on the Joint Declaration of the Denuclearization of the Korean Peninsula; the two parties agreed not to test, manufacture, produce, receive, possess, store, deploy, or use nuclear weapons; to use nuclear energy solely for peaceful purposes; and not to possess facilities for “nuclear reprocessing and uranium enrichment” (Chung and Yon 1992). Hard-line conservatives have contended that the agreement became nullified because North Korea pursued development of nuclear weapons. But the political importance and the symbolic meaning of the agreement itself cannot be completely negated.

Reprocessing Programs since 2000

With the strong opposition of KEPCO to the DUPIC fuel cycle, KAERI looked for an alternative fuel cycle in the early 2000s and focused on pyroprocessing. Pyroprocessing had originally been developed in the United States. It electrochemically separates molten salt plutonium mixed with some uranium, the minor actinides and lanthanide fission products from uranium, and fission products from spent fuel after its dissolution. The separated mixture was used as fuel for the liquid sodium-cooled reactors that Argonne National Laboratory had been developing. In 2001, Chang Yoon-il, associate laboratory director for engineering research at Argonne, persuaded Vice President Dick Cheney’s National Energy Policy Development Group that pyroprocessing might be able to solve the United States’ spent fuel problem and convinced the group that pyroprocessing is “proliferation resistant” and could be shared with other countries because it does not separate pure plutonium. The US Department of Energy (DOE) gave Argonne permission to collaborate with KAERI on pyroprocessing research (International Panel on Fissile Materials (IPFM) 2015).

Since 2005, the United States has provided funding and expertise to South Korea in support of projects related to pyroprocessing. KAERI expects this cooperation to lead to a prototype commercial pyroprocessing plant by 2025. DOE has been funding the joint pyroprocessing projects with KAERI through its International Nuclear Energy Research Initiative. In 2005, with technical assistance from the United States, South Korea built a laboratory-scale Advanced spent fuel Conditioning Process Facility (ACPF) in KAERI’s Irradiated Material Examination Facility. This facility was configured to convert oxide light-water reactor (LWR) spent fuel into a metallic form. The reason why the US government assisted KAERI’s pyroprocessing was that the US Department of State decided that “pyroprocessing is not reprocessing” at that time (Lyman and von Hippel 2008). (As noted in the discussion below of the 2015 South Korean–US agreement for peaceful nuclear cooperation, the Obama administration considered pyroprocessing to be a form of reprocessing.)
A 2009 summary report by six US national laboratories, including Argonne, examined pyroprocessing and two other proposed reprocessing technologies that arguably do not produce pure separated plutonium. The report found “only a modest improvement in reducing proliferation risk over existing PUREX (Plutonium Uranium Recovery by EXtraction) technologies and these modest improvements apply primarily for nonstate actors”, while both KAERI and Chang keep insisting that pyroprocessing is proliferation resistant (International Panel on Fissile Materials (IPFM) 2015).

KAERI argues that pyroprocessing of spent fuel and recycling of the separated plutonium is the best alternative for reducing the future burden of geologic disposal of spent fuel. The South Korean government has supported this view as well. Pyroprocessing became a major focus of the nuclear R&D program adopted in South Korea’s third five-year plan for nuclear energy R&D in 2007 (Ministry of Science and Technology (MOST) 2007). After being approved by the KAEC as a part of its action plan for development of the future nuclear power system in December 2008, pyroprocessing became a part of the national plan for nuclear power. Figure 4 shows the plan for deployment of pyroprocessing and fast reactors in South Korea. According to the plan, a demonstration pyroprocessing facility and a demonstration sodium-cooled reactor would be put into operation in 2025 and in 2028, respectively (Ministry of Science and Technology (MOST) 2007).

To make metal fuel for a fast-neutron reactor, the ceramic form of PWR spent fuel must be converted into metallic form. Pyroprocessing consists of a series of spent fuel processing stages: head end, decladding and voloxidation, electroreduction, electrefining and electrowinning. The head-end process disassembles PWR spent fuel and chops the fuel into the proper size for the decladding process. The recovered UO2 is pulverized and

![Figure 4. A draft action plan of nuclear energy R&D for future nuclear power in South Korea. Source: MOST (2007). The original figure was created by MOST and it was translated by Princeton University's Science and Global Security.](image-url)
converted into U3O8 powder by the high-temperature voloxidation process to reduce particle sizes in order to promote fast reactions in the oxide reduction process. During the voloxidation process, the volatile and semivolatile fission products are removed. The voloxidized oxide fuel is introduced into LiCl–Li2O molten salt to be reduced to metallic form. The electrolytic reduction process causes the oxide ions in the spent nuclear fuel to escape as a gas and leave the metallic spent fuel in the electrolytic cathode basket, while alkali elements and alkali earth elements are dissolved in the electrolyte. Lanthanides, except europium and other metallic fission products, remain in the cathode (Kang, Cochran, and McKinzie 2016). Figure 5 shows the steps in pyroprocessing.

KAERI has three facilities related to pyroprocessing on its site, including PRIDE (PyRoprocessing Integrated inactive Demonstration facility), the DFDF (DUPIC Fuel Development Facility) and the ACPF. The purpose of the PRIDE is to demonstrate the full spectrum of pyroprocessing performance with depleted uranium and surrogate materials in an argon-environment cell. The PRIDE has a maximum capacity of 10 tHM per year and has been in operation since 2013. The DFDF, which has been in operation since 2005, had been used for DUPIC fuel and develops key technologies for dry treatment of spent fuel. The ACPF verifies the feasibility of an electroreduction process for spent fuel in combination with the DFDF (Kim 2014).

In brief, it can be concluded that the priority of South Korea's back-end fuel cycle policies has been moved from national security to energy security, then from energy security to waste management.

Controversies Surrounding Nuclear Phaseout

Contentious Interpretations of Nuclear Phaseout

The Moon administration clarified its energy transition policy in the Eighth Basic Plan for Long-Term Electricity Supply and Demand released in December 2017. In brief,
South Korea will gradually reduce its dependence on nuclear energy and coal while increasing use of natural gas and renewable energy (Ministry of Trade, Industry and Energy (MTIE) 2017). As mentioned above, however, the total nuclear capacity in South Korea will grow during the period of the Moon administration. In that sense, the Moon administration’s “nuclear phaseout” can be understood as a long-term political slogan, and recently the government also has preferred to emphasize the aspect of “energy transition” rather than “nuclear phaseout”.

There are widely varying public survey results on the nuclear phaseout. According to a public survey conducted by Hyundai Research Institute in the summer of 2018, 85% of the respondents (1009 in total) supported the Moon administration’s energy transition policy (not exactly “nuclear phaseout” in this case), which was even higher than the previous year, and 86.6% agreed that the external cost of nuclear energy is high (Choi 2018). However, a contrasting public survey result came out a few months later. According to a public survey conducted by the Korean Nuclear Society (KNS) in October 2018, 67.9% of the respondents (1006 in total) said South Korea should maintain or even expand its nuclear capacity (Kwon 2018). The South Korean Ministry of Trade, Industry and Energy (MTIE) made a critical comment about the result by saying that the survey itself would be less credible because it was conducted by an interested party, KNS. KNS immediately objected and suggested to do a joint public survey on nuclear phaseout with MTIE if the government did not trust the result (Sul 2018). Different survey results cause conflicts among opinion leaders, scholars, politicians, the media and industries. Several callings for petitions for cancellation of the nuclear phaseout have been made on the Blue House’s national petition website.

In addition, there are increasing concerns about the slogan of nuclear phaseout from a perspective of industrial and export strategies. Regardless of its domestic nuclear phaseout policy, the South Korean government has strong interests in exporting nuclear reactors, and KEPCO had been shortlisted to bid for a nuclear project in Saudi Arabia (Chung and Kim 2018). South Korea is building the United Arab Emirates’ first nuclear reactors in the Barakah nuclear power plant. Moon highlighted strengths and advantages of South Korean nuclear reactors during his visit to the Czech Republic in November 2018, and asked Czech Prime Minister Andrej Babis to support KHNP’s bid to build a nuclear power plant in the Czech Republic (Kim 2018). The so-called nuclear establishment in South Korea and related industries are concerned that the government’s nuclear phaseout policy can be misleading to potential importers of Korean nuclear reactors and that it can undermine the credibility of Korean reactors (Chun 2017).

**Conflicts between the Central Government and the Host Communities**

Conflicts between the central government and nuclear host communities are likely to become increasingly serious. Opposition from the host communities is noticeable in North Gyeongsang Province, where nuclear facilities are concentrated. The North Gyeongsang Provincial Assembly adopted a resolution urging the central government to withdraw its policy of early closure of Wolsong 1 and requested removal of spent fuel stored at the sites (Lee 2018). Local governments in North Gyeongsang Province, such as Gyeongju and Uljin, which were directly affected by the government’s policy, urged the central government to take some measures to counteract the situation. According to the North Gyeongsang Province, the
operation rate of nuclear power plants has fallen since the Moon administration was inaugurated resulting in a significant reduction in local tax revenue. The total revenue of local resource facilities tax recorded approximately KRW 46.7 billion (approximately USD 40 million) in 2018, KRW 11.3 billion (USD 10 million) lower than the previous year’s KRW 58 billion (USD 50 million) (Son 2018).

Having had these situations, five municipalities on the east coast of North Gyeongsang Province formed the “Coalition for Coexistence of North Gyeongsang-East Coast (Gyeongbuk Donghae-an Sangsaeng Hyup-eui-hoe),” and said the coalition would submit a joint proposal to MTIE. The five municipal governments urged the central government to set up measures in response to the early closure of Wolsong 1 in Gyeongju, to resume the construction of Shin Hanul 3 and 4 in Uljin, and to provide compensation for the damage caused by the cancellation of the Chunji nuclear power plant in Yeongdeok (Son 2018). Conflicts between the central government and nuclear host communities will continue and can cause negative spillover effects on spent fuel management policy as well.

**Vicissitudes of Pyroprocessing**

**The 10-Year South Korean–US Joint Study on Pyroprocessing and the New South Korean–US 123 Agreement**

KAERI’s pyroprocessing became a negative factor in South Korea’s negotiations with the United States over the renewal of their bilateral agreement for nuclear cooperation. (Section 123 of the US Atomic Energy Act requires such agreements before the United States can engage in major nuclear cooperation with another country. These agreements therefore are sometimes called “123 agreements”.) The Obama administration was reluctant to give South Korea “prior consent” for pyroprocessing because the Obama administration saw pyroprocessing as a form of reprocessing, which means it did not fully agree with the South Korean nuclear establishment’s view of pyroprocessing as a more proliferation-resistant technology.

Because of the difficulty of the negotiations, South Korea and the United States agreed in 2011 to a 10-year joint study on pyroprocessing, to examine ways to deal with South Korea’s spent fuel challenge. The purpose of the joint study is to examine the technical, economic, and nonproliferation aspects of spent fuel management, especially the technical and economic feasibility and nonproliferation suitability of pyroprocessing. Following the completion of the joint study, South Korea and the United States will identify appropriate options for the management of spent fuel and for the development or demonstration of relevant technologies and will conduct these consultations under the auspices of the High-Level Bilateral Commission (Pomper et al. 2016). The 10-year joint study consists of three phases: Phase I (2011–2013) is for evaluation of laboratory-scale feasibility of electrochemical recycling; Phase II (2013–2018) is for determination of reliable integrated process operation with spent LWR fuel; and Phase III (2018–2021) is for evaluation of the irradiation performance of fuel fabricated from recycled LWR fuel (Kim 2014).

South Korea and the United States concluded their 123 agreement in June 2015; it entered into force in November 2015 (US Department of State 2015). The new
agreement allows KAERI to carry out research on the preparation of PWR spent fuel for pyroprocessing at ACPF – that is, conversion of the oxide form of spent fuel into the metal form by removing oxygen and some fission products, including the cesium-137 that provides the primary radiation barrier for spent fuel for decades after its discharge from a reactor. After the results of the joint study become available, the agreement could be amended at a later date if the two sides agree that pyroprocessing of the US-controlled spent fuel is necessary and can be carried out without undue proliferation risk (International Panel on Fissile Materials (IPFM) 2015). As it is allowed to use spent fuel for pyroprocessing-related research under the new 123 agreement, South Korea now can use PWR spent fuel and conduct research on decladding and voloxidation process at DFDF.

**Opposition to Pyroprocessing**

KAERI and the South Korean government have been promoting pyroprocessing as a technology that could reduce the volume of high-level radioactive waste requiring deep disposal by a factor of up to 20; the underground area required for a geologic repository by a factor of up to 100; and the toxicity of the radioactive waste by up to a factor of 1000, relative to spent fuel. However, there has been strong criticism that all these claims are false (Kang and von Hippel 2017). The South Korean government and KAERI estimate that it will cost about KRW 3.6 trillion (approximately USD 3.2 billion) to build a demonstration pyroprocessing facility and fast-neutron reactor. However, critics argue that it will cost more than expected (Kang and von Hippel 2017).

Another obstacle to the development of the pyroprocessing program is opposition from South Korean civil society. KAERI was supposed to start its electroreduction experiment to convert the oxide form of spent fuel into the metal form in July 2017. However, it has been delayed by strong local opposition. Civil society groups in Daejeon, where KAERI is located, started in late 2016 to raise strong voices in opposition to pyroprocessing. In January 2017, these citizen groups formed a coalition of 24 local nongovernmental organizations (NGOs) called the “30 km Coalition against the Nuclear Reprocessing Experiment (Haek-Jaecheori Shilheom Jeoji 30 kilo Yeondae)”. This is a significant level of civil society advocacy in opposition to the closed nuclear fuel cycle in South Korea (30 km Coalition 2017). It is unprecedented in South Korea and represents a remarkable new stage in the country’s public discourse on its nuclear fuel cycle policies.

The anti-pyroprocessing efforts of NGOs and some lawmakers in 2016–2017 succeeded in cutting 30% of KAERI’s original 2018 budget for pyroprocessing and fast-reactor R&D and imposed a condition that the Ministry of Science and ICT (MSIT) would review the R&D program. MSIT announced on 8 December 2017, that it would establish a project reexamination committee composed of seven members who are experts in areas closely related to pyroprocessing, including physics, chemistry, mechanical engineering, energy, and the environment, but who have not worked in the field of nuclear energy, to perform an objective expert review of the pyroprocessing and fast-reactor R&D project. The committee conducted a comprehensive review including technical and economic feasibility and safety, as well as past research findings, ripple effects, and diplomatic impact. The committee was scheduled to submit its final
recommendation to MSIT by the end of January 2018 (Lee 2017a). After several twists and turns, on 30 April 2018, MSIT announced that it would maintain its support for R&D on core technologies of pyroprocessing until 2020, based on the committee’s recommendations (Won 2018).

Lastly, if North Korea’s efforts toward complete denuclearization proceed and get recognized by the international society, South Korea could face more challenges from the international audience because the legitimacy of the current back-end fuel cycle policy such as pyroprocessing might be called into question as part of the international and domestic public mood opposing any recycling of nuclear material in the Korean Peninsula.

Conclusions

This article provided a historical review of South Korea’s nuclear policies, including back-end nuclear fuel cycle policies. The following points can be highlighted as concluding remarks of the analysis.

The current Moon administration’s nuclear policies seem to face two dilemmas. First, the administration aims to reduce – and ultimately phase out – nuclear power capacity; however, the country’s nuclear capacity is growing during the Moon administration, and it is not completely guaranteed that the current energy transition policy, including gradual reduction of nuclear capacity, can be fully implemented by Moon’s successors. Second, the Moon administration does not have a new vision of the back end of the fuel cycle while facing increasing spent fuel stockpiles and pursuing the denuclearization of the Korean Peninsula, and its energy transition policy can be undermined because of the absence of a new vision. These dilemmas can be better understood with the following factors in mind.

First, South Korea started to develop its nuclear program not only for energy security but also for national security, and the South Korea nuclear nationalists have been created in the context of pursuing those goals. The nuclear nationalists see nuclear capacity and the back-end fuel cycle policies as significant parts of the country’s energy and national security policies. Therefore, it becomes difficult for them to consider the socioeconomic costs of nuclear facilities and spent fuel management seriously enough. Also, their views on nuclear energy and spent fuel are not fully compatible with the Moon administration’s energy transition policies, including gradual nuclear phaseout. More specifically, it can be said that there is a wide gap between perspectives on electricity itself. The nationalistic conservatives who see electricity as a significant component of energy and national security tend to prefer nuclear as a baseload energy source, whereas others who see electricity as a type of commodity perceive socioeconomic costs of nuclear more seriously. South Korea’s electricity market is not fully privatized yet, and it is hard to say that the country has reached a consensus on whether or not electricity should be regarded as a type of commodity. In addition, how one sees nuclear energy and spent fuel is connected to how one sees the North Korean regime. The nuclear nationalists have seen North Korea as an adversary and tend to prioritize keeping spent fuel as a potential resource for South Korea’s defensive nuclear armament while others who see North Korea as a potential partner for socioeconomic integration
of the Korean Peninsula tend not to look at spent fuel from the perspective of its usefulness in making nuclear weapons.

Second, for the last several decades while nuclear energy and the back end of the fuel cycle have been regarded as significant parts of the South Korea’s energy and national security policies, the groups that make up the nuclear establishment, which share strong vested interests, have consolidated. This community includes nationalist nuclear scientists and engineers, the state-owned electricity utility companies, nuclear-related industries, conservative politicians and members of the media, and nuclear host communities. These stakeholders groups partially overlap with the nuclear nationalists described above and are likely to remain very powerful in the decision-making process on the country’s nuclear program as long as they have a professional or other stake in the outcome. On the other hand, as Korean society has become democratized and more pluralistic, liberal civil society groups who are critical of the nuclear establishment have become more politically outspoken. Contentious relations between the nuclear establishment and South Korean liberal civil society groups who have been supporting and have political leverage with Moon Jae-in and his political elites are likely to continue, which could add to the incoherence of the country’s nuclear policies in the coming years. After the Moon administration has left the Blue House, it is even possible that there will be a reversal of his policies because of these internal dynamics.

Third, the future of South Korea’s spent fuel management remains vague because of the two points mentioned above. Unless there is some fundamental change in the status quo, such as satisfactory progress in complete the denuclearization of North Korea, full privatization of the electricity utility and nuclear industry, or a moratorium on operating nuclear power plants, or unless a very strong and decisive leadership pushes forward to solve spent fuel problems within its term, the current wait-and-see stance on the growing spent fuel stockpile is likely to drag on regardless of PECOS’s recommendations. Without concrete and step-by-step actions for spent fuel management, however, it would be very difficult to fully implement the current government’s energy transition policy, including gradual nuclear phaseout.

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No potential conflict of interest was reported by the authors.

**Notes on Contributor**

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References

Choi, H. 2018. “85% of South Koreans Support the Government’s Nuclear-Coal Phaseout.” *The Hankyoreh*, June 18 (in Korean). [http://www.hani.co.kr/arti/economy/economy_general/849540.html](http://www.hani.co.kr/arti/economy/economy_general/849540.html)

Chun, J. 2017. “Controversies Rising… We Don’t Use Any More because It’s Dangerous, but We Recommend to You?” *Chosun Biz*, November 21, (in Korean). [http://biz.chosun.com/site/data/html_dir/2017/10/24/2017102402034.html](http://biz.chosun.com/site/data/html_dir/2017/10/24/2017102402034.html)

Chung, J., and C. Kim 2018. “South Korea’s KEPCO Shortlisted to Bid for Saudi Nuclear Project.” *Reuters*, July 1. [https://uk.reuters.com/article/uk-southkorea-nuclear-saudi/south-koreas-kepco-shortlisted-to-bid-for-saudi-nuclear-project-idUKKBN1JR1G4](https://uk.reuters.com/article/uk-southkorea-nuclear-saudi/south-koreas-kepco-shortlisted-to-bid-for-saudi-nuclear-project-idUKKBN1JR1G4)

Chung, W., and H. Yon. 1992. “Joint Declaration of South and North Korea on the Denuclearization of the Korean Peninsula,” February 19.

Einhorn, R., and D. Kim 2016. “Will South Korea Go Nuclear?” *Bulletin of the Atomic Scientists*, August 15. [https://thebulletin.org/2016/08/will-south-korea-go-nuclear/](https://thebulletin.org/2016/08/will-south-korea-go-nuclear/)

Ferguson, C. 2015. “How South Korea Could Acquire and Deploy Nuclear Weapons.” [http://npolicy.org/books/East_Asia/Ch4_Ferguson.pdf](http://npolicy.org/books/East_Asia/Ch4_Ferguson.pdf)

Gady, F. 2017. “Will South Korea Build Nuclear Attack Subs?” *The Diplomat*, November 8. [https://thediplomat.com/2017/11/will-south-korea-build-nuclear-attack-sub/](https://thediplomat.com/2017/11/will-south-korea-build-nuclear-attack-sub/)

International Panel on Fissile Materials (IPFM). 2015. *Plutonium Separation in Nuclear Power Programs: Status, Problems, and Prospects of Civilian Reprocessing around the World*. Princeton, NJ: IPFM.

Jang, S. 2017. “South Korea’s Nuclear Energy Debate.” *The Diplomat*, October 26. [https://thediplomat.com/2017/10/south-koreas-nuclear-energy-debate/](https://thediplomat.com/2017/10/south-koreas-nuclear-energy-debate/)

Jeong, J. 2018. “South Korea Eyes French Design for Indigenous Nuclear Sub, Sources Say.” *Defense News*, March 28. [https://www.defensenews.com/industry/techwatch/2018/03/28/south-korea-eyes-french-design-for-indigenous-nuclear-sub-sources-say/](https://www.defensenews.com/industry/techwatch/2018/03/28/south-korea-eyes-french-design-for-indigenous-nuclear-sub-sources-say/)

Jo, J. 2017. “For Moon Jae-In Administration, Topic of the Second Public Debate is Spent Nuclear Fuel.” *ETnews*, November 28 (in Korean). [http://www.etnews.com/20171128000311](http://www.etnews.com/20171128000311)

Jun, J. 2017. “Seoul May Develop Nuclear-Powered Submarine.” *The Korea Times*, November 10. [http://www.koreatimes.co.kr/www/nation/2018/12/205_239024.html](http://www.koreatimes.co.kr/www/nation/2018/12/205_239024.html)

Kang J., P. Hayes, B. Li, T. Suzuki, and R. Tanter. 2005. “South Korea’s Nuclear Surprise.” *Bulletin of the Atomic Scientists*, Jan/Feb. [https://thebulletin.org/2005/01/south-koreas-nuclear-surprise/](https://thebulletin.org/2005/01/south-koreas-nuclear-surprise/)

Kang, J. 2016. “A Nuclear South Korea Would be a Mistake.” *Bulletin of the Atomic Scientists*, April 1. [https://thebulletin.org/2016/04/a-nuclear-south-korea-would-be-a-mistake/](https://thebulletin.org/2016/04/a-nuclear-south-korea-would-be-a-mistake/)

Kang, J. 2017. “Vulnerability to Terrorism of Nuclear Spent Fuel: The South Korean Case.” *NAPSNet Special Reports*, November 30. [https://nautilus.org/napsnet/napsnet-special-reports/vulnerability-to-terrorism-of-nuclear-spent-fuel-the-south-korean-case/](https://nautilus.org/napsnet/napsnet-special-reports/vulnerability-to-terrorism-of-nuclear-spent-fuel-the-south-korean-case/)

Kang, J., T. Cochran, and M. McKinzie. 2016. “The Proliferation Resistance of a Nuclear Fuel Cycle Based on Pyrochemical Processing of Pressurized Water Reactor Spent Fuel.” Presented at ANS Nonproliferation Conference, Santa Fe, New Mexico, June 7.

Kang, J., and H. Feiveson. 2001. “South Korea’s Shifting and Controversial Interest in Spent Fuel Reprocessing.” *The Nonproliferation Review* 8 (1): 70–78. doi:10.1080/10736700108436839.

Kang, J., and F. von Hippel 2017. “Reprocessing Policy and South Korea’s New Government.” *Bulletin of the Atomic Scientists*, May 15. [https://thebulletin.org/2017/05/reprocessing-policy-and-south-koreas-new-government/](https://thebulletin.org/2017/05/reprocessing-policy-and-south-koreas-new-government/)

Kerr, P. 2004. “IAEA: Seoul’s Nuclear Sins in Past.” *Arms Control Today*, December 1. [https://www.armscontrol.org/act/2004_12/Seoul](https://www.armscontrol.org/act/2004_12/Seoul)

Kim, I. 2014. “Status of R&D Activities on Pyroprocessing Technology at KAERI.” A Summary for Symposium: Nuclear Options: Behind the US–South Korea Conflict, University of California, Berkeley, September 19.
Kim, L. 2017. “Has South Korea Renounced ‘Nuclear Hedging’?” *Bulletin of the Atomic Scientists*, June 27. https://thebulletin.org/2017/06/has-south-korea-renounced-nuclear-hedging/

Kim, Y. 2018. “Moon Asks Czech Prime Minister to Support Nuclear Reactor Bid.” *The Korea Times*, November 28. https://www.koreatimes.co.kr/www/nation/2018/11/356_259505.html

Korea Atomic Energy Commission (KAEC). 2004. “Press Release, 253rd meeting of KAEC on December 17, 2004.” (In Korean)

Korea Atomic Energy Commission (KAEC). 2016. “Draft Plan for the High Level Radioactive Waste Management.” July 25 (in Korean).

Kristensen, H., and R. Norris. 2017. “A History of US Nuclear Weapons in South Korea.” *Bulletin of the Atomic Scientists* 73 (6): 349–357. doi:10.1080/00963402.2017.1388656.

Kwon, J. 2018. “Seven out of ten Korean people said, ‘Maintain or Expand Nuclear Capacity’.” *Energy Newspaper*, November 19 (in Korean). http://www.energy-news.co.kr/news/articleView.html?idno=60340

Lee H., J. Hur, J. Kim, D. Ahn, Y. Cho, and S. Paek. 2011. “Korean Pyrochemical Process R&D Activities.” *Energy Procedia* 7: 391–395. doi:10.1016/j.egypro.2011.06.051.

Lee, K. 2017a. “Project to Reprocess Spent Nuclear Fuel Being Reexamined.” *The Hankyoreh*, December 8 (in Korean). http://www.hani.co.kr/arti/science/technology/822655.html

Lee, S. 2017b. “Gallup, ‘Supporting Nuclear Armament 60% Vs. Opposition 35%.” *The Hankyoreh*, September 8 (in Korean). http://www.hani.co.kr/arti/politics/politics_general/810212.html

Lee, S. 2018. “Resolution Calling for Withdrawal of Nuclear Phaseout Adopted.” *Gyeongju Daily*, November 23 (in Korean). http://m.gjnews.com/view.php?idx=61997

Lyman, E., and F. von Hippel 2008. “Reprocessing Revisited: The International Dimensions of the Global Nuclear Energy Partnership.” *Arms Control Association*, April 1. https://www.armscontrol.org/act/2008_04/LymanVonHippel

Ministry of Science and Technology (MOST). 2007. “A Five-Year Plan of Nuclear Energy R&D.” January (in Korean).

Ministry of Trade, Industry and Energy (MTIE). 2017. *The Eighth Basic Plan of Long-Term Electricity Supply and Demand, 2017–2031*. MTIE: Sejong. Korean.

Oswald, R. 2018. “If It Wanted To, South Korea Could Build its Own Bomb.” *CQ Weekly*, April 10. https://pulitzercenter.org/reporting/if-it-wanted-south-korea-could-build-its-own-bomb

Pomper M., T. Dalton, S. Snyder, and F. Dalnoki-Veress. 2016. “Strengthening the ROK-US Nuclear Partnership.” *CNS Occasional Paper #24*, February. https://www.nonproliferation.org/wp-content/uploads/2016/02/Occasional-Paper-24-Strengthening-ROK-US-Nuclear-Partnership.pdf

Roh, J. 2017. “The Public Deliberation Committee on Shin Kori Nuclear Reactors No. 5 & 6 Recommends Proceeding with Construction.” *The Hankyoreh*, October 20 (in Korean). http://www.hani.co.kr/arti/politics/politics_general/815317.html

Sanger, D., S. Choe, and M. Rich 2017. “North Korea Rouses Neighbors to Reconsider Nuclear Weapons.” *The New York Times*, October 28. https://www.nytimes.com/2017/10/28/world/asia/north-korea-nuclear-weapons-japan-south-korea.html

Son, S. 2018. “Five Heads of Local Governments Requested Countermeasures against Decrease in Tax Revenue by ‘Nuclear Phaseout’.” *Seoul Economic Daily*, November 20 (in Korean). https://www.sedaily.com/NewsView/1S79I6WKX4/GK02

Song, H. 2017. “Hong Joon-Pyo Said that South Korea Should Pursue Nuclear Armament if the US Declines Redeployment of its Tactical Nuclear Weapons.” *The Hankyoreh*, September 18 (in Korean). http://www.hani.co.kr/arti/politics/assembly/811538.html

State Planning Advisory Committee (SPAC). 2017. *A Five-Year Plan of President Moon Jae-In Administration*. SPAC. (In Korean)

Sul, S. 2018. “Korean Nuclear Society Suggested a Joint Public Poll about ‘Nuclear Phaseout’ to MTIE.” *Chosun Biz*, November 21 (in Korean). http://biz.chosun.com/site/data/html_dir/2018/11/21/2018112102500.html
Taylor, A. 2017. “South Korea Will Not Develop or Possess Nuclear Weapons, President Moon Says.” Washington Post, October 31. https://www.washingtonpost.com/world/south-korea-will-not-develop-or-possess-nuclear-weapons-president-says/2017/10/31/e440b2da-beaa-11e7-af84-d3e2ee4b2af1_story.html?noredirect=on&utm_term=.2a0eff844164

US Department of State. 2015. “Agreement for Cooperation between the Government of the Republic of Korea and the Government of the United States of America Concerning Peaceful Uses of Nuclear Energy,” June 15. US Department of State.

Won, H. 2018. “Supporting R&D for Pyroprocessing until 2020.” Maeil Kyungje, April 30 (in Korean). http://news.mk.co.kr/newsRead.php?year=2018&no=274944

World Nuclear Association (WNA). 2018. “Nuclear Power in South Korea.” http://www.world-nuclear.org/information-library/country-profiles/countries-o-s/south-korea.aspx

World Nuclear News. 2017. “South Korean President Accepts Public Decision,” October 23. http://www.world-nuclear-news.org/NP-South-Korean-president-accepts-public-decision-2310175.html

World Nuclear News. 2018. “Early Closure for Korea’s Oldest Operating Reactor,” June 15. http://www.world-nuclear-news.org/C-Early-closure-for-Koreas-oldest-operating-reactor-1506184.html

Yonhap. 2017. “S. Korea Starts Reviewing Nuclear Submarine Building Plan,” August 27. https://en.yna.co.kr/view/AEN20170827001200315

30 km Coalition. 2017. “Press Conference of 30 km Coalition against Nuclear Reprocessing Experiment,” January 17 (in Korean).