

# South Korea's Evolving Quest for Energy Security

## Away from Fossil Fuels and Back to Nuclear Power

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### Abstract

This article will explore Seoul's evolving energy-security strategy under the Yoon administration. It will start with an overview of South Korea's energy-security situation and a summary of the Yoon administration's new energy policies, focusing on policies to replace fossil fuels. The next sections will focus on two key factors for the Yoon administration: the potential effects of the war in Ukraine on South Korea's energy relations with Russia and attempts to bolster South Korea's domestic nuclear power industry. The latter will include a discussion of ways that South Korea can work with the United States on nuclear energy.<sup>1</sup> Finally, the article will conclude with an outlook on South Korea's energy security.

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Yoon Suk-yeol assumed the presidency of South Korea in May 2022 facing some challenges that each of his predecessors have had to deal with. Among these enduring challenges for South Korean leaders is energy security. While energy security is an issue for every country, it is a particularly acute problem for South Korea, which is highly dependent on energy imports to power its export-driven, industrialized economy. Yoon took office, however, amid a transition for South Korea's energy-security strategy, as the country is increasingly looking for ways to move away from fossil fuels to reduce carbon emissions and energy imports. Yoon's predecessor, Moon Jae-in, particularly emphasized renewable energy and hydrogen energy to replace fossil fuels, and Yoon has promised to undo Moon's nuclear phase-out policy and increase South Korea's use of nuclear power. The war in Ukraine further complicates Seoul's new energy-security calculus. South Korea had sought to expand energy relations with Russia for the past few decades, but those ties now appear uncertain.

## South Korean Energy Security under Yoon Suk-yeol

There is no single definition of *energy security* among scholars and practitioners, but this article will start with the definition used by the International Energy Agency (IEA), which defines energy security as “the uninterrupted availability of energy sources at an affordable price.”<sup>2</sup> The IEA also differentiates between long-term energy security as mainly concerning “timely investments to supply energy in line with economic developments and environmental needs” and short-term energy security as focusing on “the ability of the energy system to react promptly to sudden changes in the supply-demand balance.”

Perceptions of energy security can vary from country to country, and for Seoul, both long-term and short-term energy security have meant managing volatile international energy markets due to the country’s high energy import dependence. South Korea relies on imports for more than 90 percent of its primary energy supply, and energy imports account for around a quarter of the country’s total imports.<sup>3</sup> Moreover, high dependence on specific regions, such as the Middle East, for energy imports adds to vulnerabilities to South Korea’s energy security. Given this high energy import dependence, Herie Park and Sungwoo Bae stated that Seoul’s “top priority in energy supply security has thus been to avoid any disruption of the energy supply.”<sup>4</sup>

The importance of energy-supply security is emphasized by the fact that South Korea is among the world’s top five importers of liquefied natural gas (LNG), coal, and total petroleum liquids.<sup>5</sup> Petroleum and other liquids, coal, and natural gas accounted for 43 percent, 28 percent, and 16 percent, respectively, of South Korea’s primary energy supply in 2019.<sup>6</sup> With no road, rail, or pipeline connections to the Asian mainland, South Korea also relies exclusively on maritime shipments of the fossil fuels that deliver more than 85 percent of the country’s primary energy supply. Nuclear power and renewable energy accounted for 10 and 3 percent, respectively, of the country’s primary energy supply in 2019, but with no domestic uranium mines, South Korea is completely reliant on imports to fuel nuclear power plants, too.

One way that Seoul has sought to bolster energy security in recent years is by diversifying the country’s sources of fossil fuel supplies. South Korea imported about 69 percent of its crude oil from Middle Eastern countries—principally Saudi Arabia, Kuwait, Iraq, the United Arab Emirates (UAE), Qatar, and Iran—in 2019, but it also has increased imports from other suppliers, such as the United States, Russia, Mexico, and Kazakhstan in recent years.<sup>7</sup> Top sources of LNG imports in 2019 included the Middle East (Qatar and Oman), Australia, and Southeast Asia (Malaysia and Indonesia), and LNG shares from the United

States rose from 1 percent in 2016 to 14 percent in 2019.<sup>8</sup> Major coal suppliers in 2019 were Australia, Indonesia, Russia, and Canada.<sup>9</sup> Diversifying fossil fuel suppliers can increase energy security by being able to respond to short-term and long-term changes to the fossil fuel markets, but it also means that Seoul must manage many energy import relationships and be concerned about multiple primary sea lanes for shipping.

This is the energy-supply structure that the Yoon administration inherited earlier this year, but the administration released its own view of South Korea's energy-security situation in July 2022. The Republic of Korea (ROK) Ministry of Trade, Industry and Energy (MOTIE) stated, "Amid the global push for carbon neutral, escalation of Russia-Ukraine conflict and global energy-supply chain uncertainties, energy security and attaining carbon neutral goals are now more critical than ever."<sup>10</sup> MOTIE did not set overall energy mix goals but set a goal of having nuclear power deliver 30 percent of South Korea's electricity by 2030. It emphasized having market principles guide policies on other energy sources and using energy industry exports as growth engines for South Korea's economy.

MOTIE also did not set a date for South Korea's economy to become carbon neutral but emphasized realizing carbon neutral goals as imperative for South Korea's energy security. Pursuing carbon neutrality surely is motivated for environmental reasons; however, the new energy policy announcement ended with arguably an equally important reason for this pursuit. MOTIE claimed that implementing the Yoon administration's energy policies "will help reduce reliance on fossil fuel imports from 81.8 percent (2021) to 60 percent (2030)."<sup>11</sup>

Successfully moving away from fossil fuels, thus being less reliant on energy imports, could help South Korea meet the IEA's definitions of both long-term and short-term energy security. In the short-term, South Korea will remain heavily reliant on energy imports, but the war in Ukraine highlights the need to pursue more stable import relationships while transitioning away from fossil fuels. In the long-term, investments in nonfossil fuel energy sources, like nuclear power and renewables, will be vital for South Korea's energy security. This article now turns to the impact of the war in Ukraine and revitalizing South Korea's domestic nuclear power industry, key factors for implementing the Yoon administration's energy policy.

### **Impacts of Russia's War in Ukraine on ROK Energy Security**

Seoul has been interested in importing fossil fuels from reserves in the Russian Far East since the late 1980s to diversify ROK energy imports. In 1992, South Korean and Russian leaders agreed to study the joint development of natural gas fields in the Russian Far East and gas pipelines from Russia to South Korea.<sup>12</sup> In

the following decades, the two countries explored jointly developing natural gas and oil fields in the Russian Far East, an oil complex in the Vladivostok area, and a power grid interconnection project involving North Korea.<sup>13</sup>

These efforts by South Korea produced some substantial results, as energy imports from Russia gradually rose in the past few decades. By 2021, imports from Russia accounted for about 9 percent of all fossil fuel imports by South Korea, including 5 percent of LNG imports, 6 percent of crude oil imports, and 17.5 percent of coal imports.<sup>14</sup> Pipelines or power lines connecting Russia and South Korea did not materialize, and difficulties cooperating with China and North Korea on such projects significantly contributed to those failures.

Yet, Se Hyun Ahn argued that other factors have limited broader energy cooperation between Russia and South Korea. He wrote that Seoul–Moscow relations “have not facilitated greater cooperation in energy projects” and that “South Korean investors have been skeptical about investing in Russia because of the unstable political and economic situation and Russia’s patchwork reform.”<sup>15</sup> He added that Moscow views fossil fuel exports as a tool to restore Russia’s status as a great power, which has had Russian leaders reluctant to make more structural reforms or encourage more foreign cooperation in energy projects.<sup>16</sup> Kent Calder similarly argued that natural gas pipelines can give the exporter leverage over the importer and wrote that Russia has used pipelines through Moldova and Ukraine as political leverage over those two countries.<sup>17</sup>

Russia’s invasion of Ukraine further complicates South Korea’s views of energy cooperation with Russia and makes Moscow appear to be a more politically unreliable energy partner. After Seoul agreed in March 2022 to enforce sanctions on Russia for the war in Ukraine, Moscow responded by designating South Korea an unfriendly country and demanding that unfriendly countries pay for natural gas imports in rubles.<sup>18</sup> This did not immediately stop energy cooperation between the two countries, as South Korea continued to import LNG from Russia at levels similar to 2020 and 2021 through the first half of 2022.<sup>19</sup> Yet, previous concerns about Russia using fossil fuel exports as political leverage and generally being an unreliable energy partner may be coming to fruition now.

These political concerns with Russia are combined with rising global energy prices. Global prices for coal, natural gas, and oil all have steadily risen since mid-2020, with coal and natural gas prices rising sharpest. Global energy prices were rising before Russia invaded Ukraine, but the war in Ukraine exacerbated this trend and has made importers of Russian fossil fuels begin to look for alternative ways to meet their energy needs.

Seoul’s energy relationship with Russia is further strained by continued tension with North Korea that has prevented any progress on pipelines from Russia to

South Korea. Calder forecast on South Korea's energy future and said the following about what South Korea would do when facing high global energy prices and tension with North Korea: "Should global energy prices prove to be high and should the political status quo in North-South relations remain ambiguous or turn more hostile once again, nuclear reliance could have a compelling logic for Korea as a whole. This would be particularly true if North-South political disputes prevent the realization of a trans-Korea gas pipeline."<sup>20</sup> The war in Ukraine only adds to this logic pushing the Yoon administration to reemphasize the use of nuclear power in South Korea.

### **Potential Nuclear Renaissance in South Korea**

South Korea's civil nuclear program goes back to the 1960s, but the country's first major push toward nuclear power came in the 1970s, in the wake of the 1973 oil crisis.<sup>21</sup> South Korea's first commercial nuclear reactor, Kori-1, entered commercial operation in 1978, and nuclear power quickly grew to providing more than 50 percent of the country's electricity by 1987.<sup>22</sup> While other power sources also grew in subsequent years to balance out the ROK's power sector, South Korea remains one of the top users of nuclear power in the world. South Korea's nuclear industry was among the top six countries in the world in terms of operable reactors, net electrical capacity, and electricity supplied in 2021, and nuclear power accounted for 28 percent of the country's electricity that year.<sup>23</sup>

Despite the prominence of nuclear power in South Korea's energy portfolio since the 1970s, previous ROK president Moon Jae-in initiated a policy to phase out nuclear power due to concerns regarding safety and long-term viability of the nuclear industry. The phase-out policy mostly consisted of not starting new reactor construction projects and shutting down existing reactors when they reached 40 years of operation. South Korea's two oldest reactors, Wolsong-1 and Kori-1, shut down during Moon's presidency, but the relative youth of the country's reactor fleet meant that the phase-out policy would take until about 2060 to complete. Thus, when Yoon took office in May 2022 with a campaign promise to reverse the phase-out policy, he still inherited a robust nuclear sector. However, it is a sector in need of more stability and support to be able to meaningfully contribute to South Korea's pursuit of carbon neutrality and reduced dependence on fossil fuel imports.

The Yoon administration has moved to support South Korea's nuclear sector rhetorically and financially. MOTIE's new energy policy announcement declared that "it is imperative that new energy policy goals and directions are set so as to better accomplish carbon neutral government projects and the expansion of nuclear power."<sup>24</sup> MOTIE also set three targets for the country's nuclear industry to

achieve by 2030: account for 30 percent of the country's electricity, export 10 nuclear power plants, and develop a unique small modular reactor (SMR).<sup>25</sup> Financially, the Yoon administration said they will increase funding for nuclear research-and-development projects and government-backed loans for companies working with the nuclear industry.<sup>26</sup>

Yoon also is looking to bolster cooperation with South Korea's oldest nuclear energy partner, the United States, to help strengthen his country's nuclear industry. Yoon and US president Joe Biden met in May 2022 and proclaimed that they "recognize the importance of nuclear energy as a critical and reliable source of carbon-free electricity, an important element to grow our clean energy economy, and an integral part of enhancing global energy security."<sup>27</sup> They committed to increasing civil nuclear cooperation, particularly in the areas of advanced SMR development, assured fuel supply, and spent nuclear fuel (SNF) management.<sup>28</sup> This article will now look at how South Korea can cooperate with the United States in these three areas.

### **Opportunities for US-ROK Cooperation**

The first area of cooperation is the development and deployment of advanced SMRs. The existing fleets of commercial reactors in South Korea and the United States comprise large-scale reactors that are designed to provide stable baseload power for the electricity grid. Except for four heavy-water reactors in South Korea, all are light-water reactors (LWR). These reactors have successfully provided carbon-free electricity generation for several decades in both countries. Nevertheless, there does not appear to be strong demand for building more of these types of reactors, especially in the United States, largely due to high upfront capital costs. The recent attempts to build large LWRs in the United States do not provide much reason for optimism. Construction on two new LWRs each at the VC Summer nuclear power plant in South Carolina and the Vogtle nuclear power plant in Georgia began in 2013. The project at VC Summer ceased in 2017, and while construction continues at Vogtle, those two reactors are well behind schedule and over the initial budget estimate. These experiences led to the bankruptcy of Westinghouse Electric Company and dampened hopes for building additional large LWRs in the United States.

Even as these larger reactors face challenges, there is optimism for advanced SMRs. There is no common definition of an SMR, but it generally has one-third or less the generating capacity of a traditional LWR, with capacities ranging from tens of megawatts up to around 300 megawatts. SMRs can be based on traditional LWR technologies, but they also can use other coolants, such as gas, liquid metal, or molten salt. SMRs have been touted for a variety of uses, including power

generation, process heat, and desalination. Thus, SMRs could contribute to decarbonization across various economic sectors. The US Department of Energy (DOE) has promoted the development of advanced SMRs for several years, citing “relatively small physical footprints, reduced capital investment, ability to be sited in locations not possible for larger nuclear plants, and provisions for incremental power additions” as among the main advantages of SMRs over traditional LWRs.<sup>29</sup>

Collaboration between South Korean and US firms on SMR development is already under way. For example, Doosan Enerbility and Samsung C&T both recently completed agreements with NuScale Power related to the construction of NuScale’s 50 megawatt SMR.<sup>30</sup> NuScale plans to begin operating its first SMR in the US state of Idaho by 2029 and is exploring other opportunities in Europe and Asia. SK Group is considering investing a 10-percent stake in TerraPower, which plans to build its first demonstration reactor in the state of Wyoming by 2028.<sup>31</sup> Finally, Hyundai Engineering & Construction signed an agreement for the turnkey supply of Holtec International’s SMR in 2021, which is considering building an SMR in the state of New Jersey.<sup>32</sup>

These examples are similar to the US–ROK collaboration at the Barakah nuclear power plant in the UAE, where South Korean firms led construction and component supply and US firms provided design and service support. With South Korea’s more recent success in nuclear reactor construction, it only makes sense that US nuclear design firms would look to South Korean firms for construction and component supply. Moreover, the provision of South Korean financing, such as SK Group’s interest in TerraPower, could prove vital to actualizing SMR deployment in the United States by 2030.

A good next step would be for US firms such as NuScale to explore options for siting an SMR project in South Korea, despite facing competition from domestic South Korean SMR designs. However, with South Korean firms planning to provide construction, component, and financing services, even US-based SMR designs would benefit South Korean nuclear firms. Selecting an existing US-based design that is already moving toward deployment could speed up SMR deployment in South Korea. The Yoon administration should set a goal of starting construction on an advanced SMR by 2027, which would put the country on a similar timeline to SMR deployment in the United States. Siting such a project would be challenging, but South Korea could explore similar options as US SMR siting plans, such as at national laboratories or at existing power plant sites.

The nuclear industries in both countries have faced challenges with siting and financing before, but a new challenge related to fuel supply has now arisen due to Russia’s invasion of Ukraine and subsequent economic sanctions imposed on Russia by the United States and allies. Russia’s Techsnabexport (Tenex) supplies

around 20 percent of the low-enrichment uranium (LEU), which is typically enriched to between 3 percent and 5 percent for US LWRs, and it signed a new contract in 2020 to supply uranium-enrichment services for South Korean LWRs through 2030.<sup>33</sup> Moreover, most of the advanced nuclear reactors under development in the United States require high-assay low-enriched uranium (HALEU), enriched to between 5 percent and 20 percent.<sup>34</sup> The United States currently has no capacity to produce HALEU, and Russia was expected to supply this uranium for at least the initial advanced SMRs in the United States. There are new calls in the United States to increase domestic uranium-enrichment capacity, including for HALEU production, so that advanced SMR deployment is not delayed due to the political or economic effects of the war in Ukraine.

The DOE has two programs—the Strategic Uranium Reserve and HALEU Availability Program—that could address this need to increase domestic uranium-enrichment capacity. The DOE’s National Nuclear Security Administration (NNSA) initiated purchases for the former program this past summer, and for fiscal year 2023, the White House requested USD 1.5 billion for the latter program.<sup>35</sup> The HALEU Availability Program would commit the DOE to buy some of the first batches of HALEU, thereby supplying needed market certainty for uranium-enrichment providers to produce HALEU and for advanced SMR developers to proceed with deployment plans. Time is of the essence here, as processing a license to modify an existing uranium-enrichment facility or to build a new facility would take two to four years.<sup>36</sup> The only licensed enrichment facility in the United States is operated by Urenco and can produce up to 5.5 percent LEU. Centrus Energy’s license to produce up to 20 percent HALEU at a demonstration project site will end later this year, and the firm said it would take four years to bring a commercial facility online after securing funding or purchase commitments.

Thus, increasing HALEU production capacity is another area where South Korea and the United States could deepen their civil nuclear cooperation. South Korea has no uranium-enrichment capacity and would need permission from the United States to enrich uranium, per the terms of the two countries’ 123 Agreement from 2015.<sup>37</sup> Yet, as with advanced SMR development, South Korea could provide financing to help increase US uranium-enrichment capacity. For example, TerraPower’s Sodium reactor requires HALEU, and SK Group could further support TerraPower’s deployment plans by investing in or signing a purchase agreement for US-produced HALEU.<sup>38</sup> Other advanced SMR designs—including those by NuScale, Holtec, and the Korea Atomic Energy Research Institute’s SMART SMR—use standard LEU. Thus, South Korean investments in expanding any uranium-enrichment capacity in the United States would be beneficial.

The 123 Agreement also established the High-Level Bilateral Commission specifically to address issues such as “assured stable fuel supply.”<sup>39</sup> A meeting of the commission to address this uranium-enrichment challenge for advanced SMR deployment could explore such opportunities for South Korean support for domestic LEU and HALEU production in the United States. Increasing US enrichment capacity, in partnership with South Korean firms, would also help the United States and South Korea present a more competitive, full-service package for nuclear reactor exports to third countries, which is something the nuclear industries in both countries have desired for many years.

While there should be much focus over the next five years on supporting advanced SMR deployment and assured fuel supply, the existing fleets of nuclear reactors in both countries should not be ignored. Many of these reactors are slated to operate for decades to come, but others will be shut down and enter decommissioning in the coming years. Operating and decommissioning legacy reactors present opportunities for advancing US–ROK civil nuclear cooperation.

For operating reactors, the US and ROK nuclear industries have worked to increase fleetwide capacity factors, and reactor capacity factors have topped 90 percent in both countries in recent years.<sup>40</sup> This does not leave much room for improvement. Nonetheless, continued sharing of best practices in reactor operations can help ensure that existing reactors continue to operate with high-capacity factors. In addition, South Korea can learn from how US reactors continue operating beyond 40 years. Initial reactor licenses in both countries are for 40 years, but many reactors in the United States are now slated to operate up to 60 years or more. As South Korea's reactor fleet ages, reactor operators and regulators in both countries should increase information exchanges on safe, efficient reactor operations beyond 40 years.

Not all reactors will operate beyond 40 years, and safely decommissioning reactors is an important part of the nuclear industry's long-term viability. The first two reactors to shut down in South Korea came recently in 2017 and 2019.<sup>41</sup> The Moon administration announced plans in 2019 to bolster South Korea's decommissioning capabilities, but this development is still in early stages and will require several more years to acquire the necessary technologies.<sup>42</sup> Partnering with US firms that have significant decommissioning experience, such as Holtec, could speed up South Korea's acquisition of decommissioning technology. Such corporate partnerships also could bolster US–ROK nuclear reactor exports by offering better end-of-life services to customers.

Related to reactor operation and decommissioning is SNF management, which is a challenge that the nuclear industry has struggled to address for decades. Neither the United States nor South Korea has a long-term SNF management plan

in place, but the two countries recently concluded a 10-year joint fuel cycle study on using pyroprocessing and sodium-cooled fast reactors (Pyro-SFR) to process and better manage SNF.<sup>43</sup> Development and deployment of a Pyro-SFR system is a long-term project. In the meantime, the United States and South Korea could work together on expanding the use of dry casks for interim storage of SNF. Siting interim and long-term storage facilities for SNF is an ongoing challenge that could be addressed through technological cooperation and information exchanges. Doing so is necessary for the current and future viability of nuclear power.

Cooperating with the United States in these areas could significantly strengthen South Korea's domestic nuclear sector and could improve Seoul's export competitiveness. Despite Moon's policy to phase out nuclear power domestically, his administration supported nuclear technology exports, like the Yoon administration's support for nuclear exports. A May 2021 joint statement between Moon and Biden committed the two countries "to develop cooperation in overseas nuclear markets, including joint participation in nuclear power plant projects."<sup>44</sup> Yet, a domestic nuclear phase out likely would reduce South Korea's competitiveness in the export market, and areas for cooperation with the United States would also be limited domestically and internationally. Without a domestic market, South Korea likely would see a decrease in its nuclear-related labor force and in manufacturers certified to produce components for nuclear reactors, which would weaken the broad industrial base necessary for nuclear reactor construction. Thus, the Yoon administration's political and financial support should provide a boost for South Korea's domestic nuclear industry, improve export competitiveness, and expand areas for US–ROK cooperation, providing an opportunity to secure the future of nuclear power in both countries' push for carbon neutrality.

## **Conclusion**

South Korea's move away from fossil fuels is driven by desires to improve the natural environment and to bolster energy security through reduced dependence on fossil fuel imports. At the 2021 United Nations Climate Change Conference (often referred to as COP26), South Korea pledged to reduce carbon emissions by 40 percent from 2018 levels by 2030, equaling nearly 270 million tons of emissions. Troy Stangarone wrote that South Korea could cut roughly 73.5 million tons by 2030 by replacing imports of Russian fossil fuels with nonfossil fuel energy sources.<sup>45</sup>

Not all these imported fossil fuels are used in the power sector, but the reemphasis on nuclear power by the Yoon administration could help South Korea replace Russian fossil fuels with nonfossil fuel energy sources. Completely replacing Russian fossil fuel imports and achieving carbon neutrality by 2050 will require

that other energy sources—like solar, wind, and hydrogen—be developed and deployed on a much larger scale than their current utilization. Cooperation with the United States and other more politically stable partners will be critical for the Yoon administration and future South Korean governments to improve the country's energy security by reducing fossil fuel imports and related carbon emissions.

For short-term energy security, the Yoon administration must take measures to deal with rising global energy prices and supply-chain disruptions—both partly caused by the war in Ukraine. Fossil fuel imports from Russia cannot be cut off immediately, unless Moscow decides to do so, due to long-term contracts and time needed to transition energy systems, but South Korea can start looking now to increase fossil fuel imports from other countries, such as the United States. Other demand-side measures, like energy conservation and government support for consumers, also can be considered to improve short-term energy security.

For long-term energy security, the measures that the Yoon administration takes to move South Korea away from fossil fuels, such as revitalizing the domestic nuclear power sector, will be critical for achieving carbon neutrality and significantly reducing energy import reliance. Complete energy independence is likely an unrealistic and undesirable goal. Uranium will need to be imported for nuclear power plants, and some fossil fuel imports for industrial and energy use will likely be needed for the foreseeable future. Import capacity and relationships also help hedge against possible domestic energy shocks in the future. However, transitioning energy systems takes on the order of decades, so the Yoon administration is facing a critical time for South Korea to be able to transition the country's economy away from fossil fuels by 2050. ♣

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## Notes

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### **Disclaimers**

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