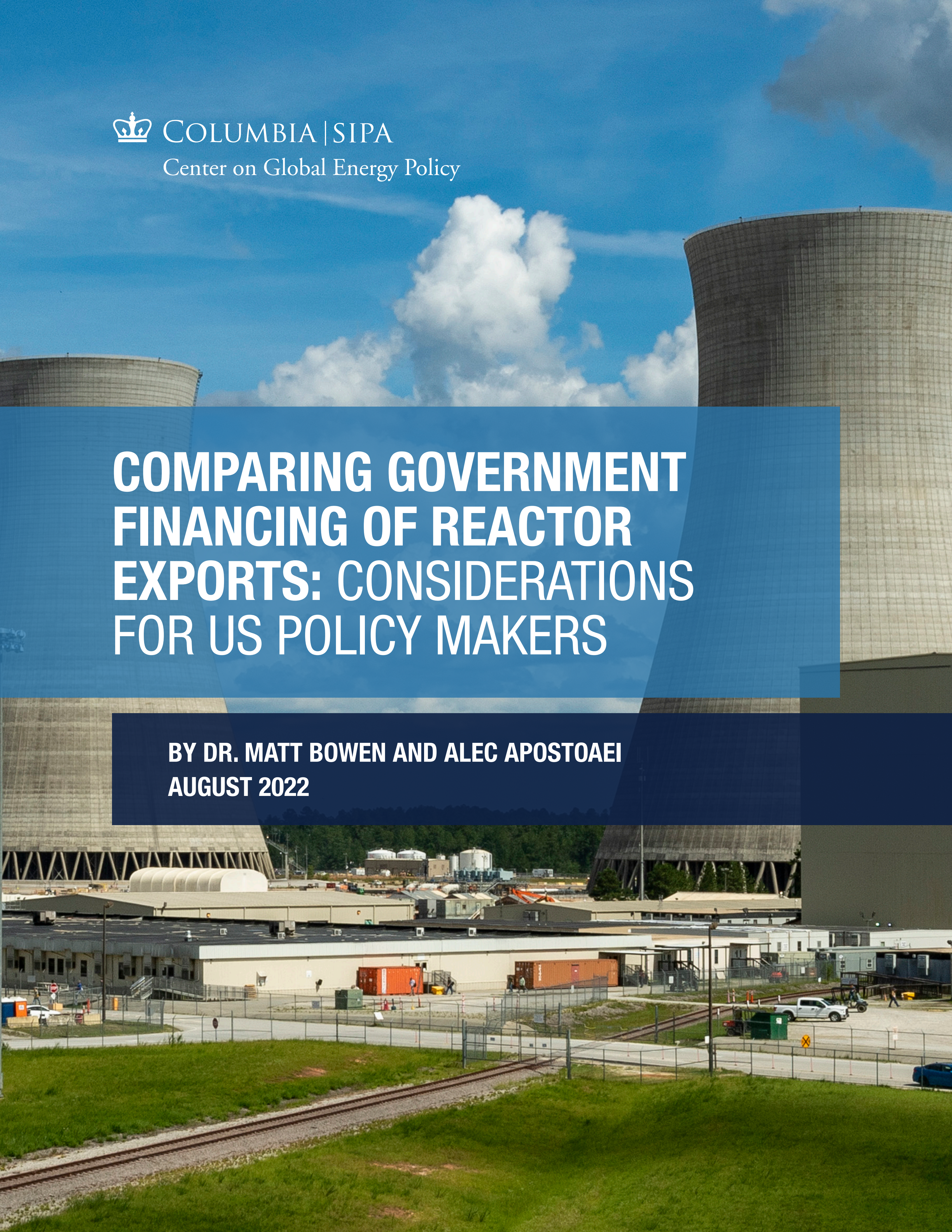

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COMPARING GOVERNMENT FINANCING OF REACTOR EXPORTS: CONSIDERATIONS FOR US POLICY MAKERS

BY DR. MATT BOWEN AND ALEC APOSTOAEI

AUGUST 2022

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Cover source: Photograph courtesy of Georgia Power Company.

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EXECUTIVE SUMMARY

Decarbonizing the world's energy supply by 2050 will require financing low-carbon energy projects at a cost of upwards of trillions of dollars. Nuclear energy is one of the few dispatchable low-carbon energy resources, and studies by the International Energy Agency have estimated a possible doubling of nuclear power as part of scenarios for achieving net-zero greenhouse gas emissions by midcentury. Large, capital-intensive projects such as nuclear power plants can be challenging for some countries to finance, however. As a result, countries wishing to build nuclear reactors look for attractive financing from supplier nations in the form of loans and equity.

This report, part of wider work on nuclear energy at Columbia University's Center on Global Energy Policy, compares the financing terms offered between 2000 and 2021 by the world's major exporters of nuclear power plants: Russia, France, the Republic of Korea (ROK), China, and the United States. Russia dominated this period, with 11 reactors connected to power grids in six countries, in part due to the attractive state-backed financing offers it made. At the beginning of 2022, Russia had 13 of its reactors under construction in other countries, more than all other countries' reactor exports combined.

The US government has been actively developing advanced reactor technologies, partly with the intention of exporting them to other countries to help them address their energy and environmental goals. However, for numerous reasons, the US government has not financed a new US reactor export in decades, even though the US Export-Import Bank (EXIM) and the new International Development Financing Corporation (DFC) are capable of supporting exports of this scale. Given the recent absence of US financing, this report analyzes the earlier activities of EXIM related to nuclear energy and their relevance for potentially reviving such financing efforts in the near or medium term.

A key factor shaping reactor vendor competitions is a nuclear arrangement by the Organization for Economic Co-operation and Development (OECD), in which France, the ROK, and the United States are members but China and Russia are not. This arrangement places limitations on OECD members regarding key loan terms for their reactor exports, including minimum interest rates and loan repayment terms, that can put them at a disadvantage compared to state-owned vendors from Russia and China. The arrangement does not restrict equity investments in reactor exports, posing an additional disadvantage for private vendors in the United States as they compete with larger, state-owned vendors in France and the ROK.

As other countries develop their civil nuclear energy programs or begin new ones, the US government will need to decide whether it will assist in financing US reactor exports. The federal government has a variety of potential rationales for doing so, including creating jobs, assisting other countries in overcoming their energy and environmental challenges, and limiting Chinese and Russian influence. On the other hand, financing from EXIM or the DFC will come with financial risk, as some individual projects may not have successful outcomes.

This report ultimately makes a set of recommendations to US policymakers, should they seek to strengthen the role of the United States in the international nuclear export market:

- First and foremost, the White House National Security Council should convene meetings with EXIM, DFC, and other agencies involved in civil nuclear energy policymaking to review the importance of federal financing and other government support mechanisms in determining customer country selection outcomes for nuclear builds and how US interests are affected by these outcomes.
- Second, Congress should ensure that EXIM in particular can effectively match offers from Russia and China, and could expand the focus of the EXIM transformational exports program beyond renewable energy to include all low-carbon energy technologies, including nuclear reactor facilities.
- Third, the US government should seek to strengthen nuclear energy cooperation between the United States and its allies to aid competitiveness against Russia and China. For example, given that some content in any US reactor export will likely come from US allies, these latter countries could contribute to financing those exports.

INTRODUCTION

Decarbonizing the world's energy infrastructure by 2050 will involve constructing low-carbon energy projects that cost trillions of dollars. Financing the construction of those projects is one challenge involved in the energy transition. As the International Energy Agency (IEA) has noted, "Supportive international actions will be essential to catalyse the necessary investments in critical areas…starting with the commitment by development economies to mobilise USD 100 billion per year in climate finance."[1] Other research has estimated that dramatically lowering the carbon intensity of the world economy may require investment ranging from $92 to $173 trillion over the next three decades.[2]

At the 26th Conference of the Parties (COP26) climate summit in November 2021, the United States and 38 other countries agreed to prioritize support for a clean energy transition, end new support for unabated fossil fuel use, and encourage "governments, their export credit agencies, and public finance institutions to implement similar commitments into COP27 and beyond."[3] The commitment by some countries to end financing of new coal plants and a more general commitment to phase down the use of fossil fuels raises the question of what will be used in place of those dispatchable sources of energy. Analysis has shown that the costs of transitioning to a low-carbon electrical grid are mitigated by the availability of firm, low-carbon generation capacity to maintain grid reliability.[4]

One firm, low-carbon generation capacity option that can replace existing dispatchable coal and natural gas power plant capacity is nuclear power, which is already widely deployed around the world, making up 10 percent of global electricity generation. China, for example, plans to build dozens of new nuclear reactors (tens of gigawatts of capacity) in the next 10 years alone as part of achieving its stated goal of net zero carbon emissions by 2060. As the IEA has assessed, nuclear power plants can help limit the impact of seasonal fluctuations in output from variable renewable resources and bolster energy security through reduced dependence on imported fuels.[5]

In recent years, the US government has been actively developing small modular reactor (SMR) technologies. One rationale for these programs is the intention of exporting them to other countries to help them address their energy and environmental goals. For example, at COP26, Special Presidential Envoy for Climate John Kerry and Romanian President Klaus Iohannis announced Romania's intention to build a first-of-its-kind US SMR to help Romania address its energy needs while also reducing greenhouse gas emissions.[6] Specifically, these SMRs could replace baseload power from retiring coal plants in the country.

One question in the case of Romania and elsewhere is how new nuclear reactor projects will be financed. The construction of new power plants can cost in the billions of dollars, even in the case of new "small" reactors under development. Nuclear power plant construction is typically financed through a combination of debt and equity procured from multiple sources. Debt financing involves borrowing money (e.g., a bank loan), defining a time period for repayment—with the first payment typically occurring about six months after the reactor begins operation—and setting an interest rate that will be charged on the loan. To take an overly simple example, if a US utility company wanted to build a $4 billion nuclear power plant, it might use $2 billion of its own money (i.e., make an equity investment in the project) and take out a $2 billion loan[7] from a bank to cover the total cost of construction. The utility would then, at a predetermined date, make payments to the bank on the loan until it was fully paid back (with interest). Only after the nuclear plant began producing and selling electricity to generate revenues might the utility begin to see a return on its equity investment.

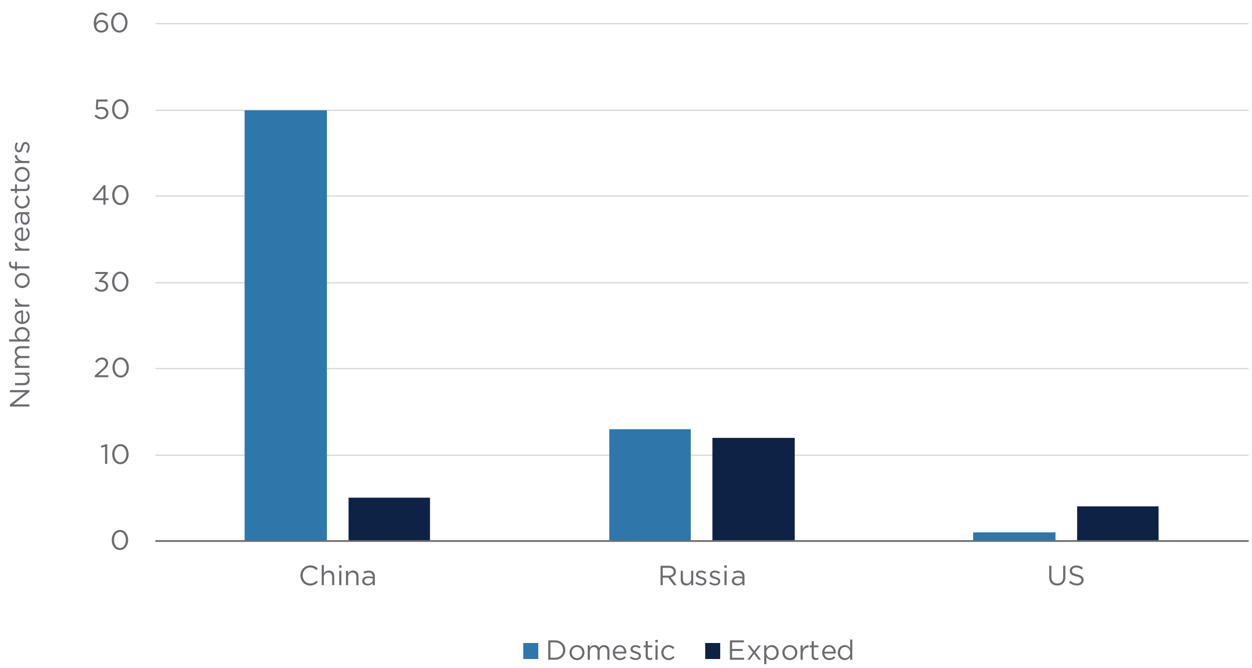
As this report conveys, government-assisted financing in support of reactor exports from a supplier country is a standard component of negotiations and is expected by most customer nations. The US government has not provided financing in support of new US reactor exports in decades. In the context of both assisting other countries with decarbonizing their electrical grids and competing with Russia and China (as well as allies like France and the Republic of Korea), the US government's approach to financing US reactor exports (or not financing them) will to some degree determine the role of the United States in future international reactor commerce. Other factors that may affect US competitiveness in this space include the overnight cost of advanced reactor designs and the confidence that a given supplier will deliver what they promise in terms of cost and schedule.

Relevant to competition among reactor vendors, the United States, France, and the Republic of Korea (ROK) are all members of the Organisation for Economic Co-operation and Development (OECD), but China and Russia are not. The OECD maintains a list of the export credit agencies[8] within OECD countries that provide financing in support of a broad range of national exports as well as the Arrangement on Officially Supported Export Credits, an agreement with respect to the financing of those exports, including nuclear reactors. This "gentlemen's agreement" places limitations on, for example, the loan terms that OECD countries may make to customer countries in support of reactor exports, including for key terms such as minimum interest rates (tying them to national government bond rates), risk premiums based on assessed default risk, the percentage of import content and local content that an export credit can cover (no more than 85 percent of imported content and—prior to 2021—no more than 30 percent of local content), and the length of a loan repayment term (no longer than 18 years for a nuclear project).[9] It does not, however, place restrictions on a supplier country's equity investment in its reactor export projects from state-backed sources.

Russia and China—again, not being members of the OECD—are not committed to these guidelines and, as later chapters demonstrate, have at times made financing offers in support of their reactor exports that are more generous than the OECD Arrangement allows. In recent years, the US government has grown increasingly concerned about the declining role of the United States in the international nuclear energy marketplace amid the current export dominance of Russia and the expected rise of China in the international nuclear energy marketplace due in part to its aforementioned large domestic build program.[10] These trends are illustrated in Figure 1 and Table 1. Part of this concern is linked to other countries' potentially greater interdependence and alliance with Russia and China and increased Russian and Chinese influence over nuclear safety, security, and nonproliferation standards and supplier norms.

This report compares reactor export financing terms among the major suppliers with the aim of informing US decisionmakers in Congress and the executive branch of the challenging landscape that private US reactor companies face in international nuclear commerce. The financing resources that these foreign state-owned entities are able to bring to the table in support of their reactor exports will be difficult for comparatively smaller, private US companies to match by themselves. US policymakers will very likely need to grapple with these issues if they want a role for the United States in the international nuclear energy market for geopolitical and/or national security reasons. The recommendations at the end of the report provide actions that US decisionmakers could take to grapple with and potentially improve US competitiveness in the reactor supply arena.

Figure 1: Reactors connected to electrical grids (2000–2021)



Note: Domestic reactors in China include those supplied by Russia, France, and the US, in addition to those from China's own build program.

Source: IAEA PRIS.

Table 1: Reactors under construction at the beginning of 2022 for Russia, China, and the United States

Country	Domestic reactors under construction	Exported reactors under construction
Russia	4	13
China	15	1
United States	2	0

Source: IAEA PRIS.

As a starting point for such a comparison, this report examines the nuclear power reactors that were connected to national electrical grids between 2000 and 2021, as well as the reactors under construction at the beginning of 2022—both cataloged in the IAEA power reactor database.[11] A reactor connected to a national grid is considered to be an export if the design originated in another country.[12] While loan agreements involve many important details (e.g., fines for missed payments, the date that repayment begins, risk premiums, and financing fees), this report focuses on three of the most basic ones: total amount in dollars or euros, interest rate charged, and length of the repayment term in years.[13] Equity investments from supplier countries are compared as a percentage of total project costs.

There are two countries that exported reactors during the last twenty years that are not examined in subsequent chapters: Germany and Canada. Germany exported Siemens-designed reactors to Brazil (Angra-2 in 2000) and Argentina (Atucha-2 in 2014). After the accident at the Fukushima nuclear power plant site in Japan in 2011, however, Germany decided to exit nuclear energy, and Siemens announced it would withdraw its remaining nuclear power offerings and leave the industry.[14] For that reason, Germany is not examined as part of the major suppliers in this report.

Likewise, decades ago, Canada fielded a large domestic pressurized heavy water reactor program and exported Canada Deuterium Uranium (CANDU) reactors to other countries, including after 2000. The last CANDU to be connected to any grid was in 2007, however, and none are currently under construction or being planned.[15] The Ontario Power Generation company—the largest owner of CANDUs in Canada—recently selected GE-Hitachi to move forward with developing a first-of-a-kind light water SMR,[16] which would indicate that the future direction of Canada's nuclear program is not its domestic CANDUs. For that reason, Canada is not considered a major supplier here.

With Germany and Canada excluded, the report focuses on the following five supplier countries and associated reactor exports, which were included on the basis that they were deployed in another country: Russia (all VVER models and BN-20); China (CNP-300 and ACP-1000, also known as the "Hualong One"); France (M310 and evolutionary pressurized reactors); the ROK (APR1400); and the United States (AP1000). The discussion proceeds as follows. Chapter one examines Russia's financing offers in support of its reactor exports, which during 2000–2021 were greater in number than the sum of all of those delivered by the other three suppliers that compete with the United States. Chapter two analyzes the terms of the financing offers of those three countries—France, China, and the ROK. Chapter three explores the integral role that financing played in the early years of the US government's Atoms for Peace program as well as more recent relevant policy developments. Chapter four offers recommendations for Congress to aid US competitiveness as well as actions for the executive branch in this direction.

For Russia, the report relies on intergovernmental agreements from Russian governmental websites and Russian legal websites, international news reporting, statements from both Russian media and government officials, and news reporting from customer nations. For France, China, and the ROK, it uses international news reporting, government documents, company press releases, and, specific to the case of China, the website china.aiddata.org, which is dedicated to collecting data on that country's overseas development finance activities. For the historical analysis in chapter three, the report draws on EXIM annual reports and press releases from the bank's digital archives website (digitalarchives.exim.org).[17] (The early history of financing for US reactor exports is addressed in Appendix 3.) Examples of recent financing projects by EXIM and the new US International Development Financing Corporation (DFC) at a scale that is comparable to what would be needed to support reactor exports are drawn from the EXIM and DFC websites.

CHAPTER 1: RUSSIA

Between 2000 and 2021, 11 Russian water-water energetic reactors (VVERs) were connected to electrical grids in Belarus, China, the Czech Republic, India, Iran, and Ukraine. At the end of 2021, 13 VVERs were under construction in Bangladesh, Belarus, China, India, Iran, Slovakia, and Turkey.[18] Russia's state-owned nuclear energy corporation, Rosatom, lists three additional reactor projects under development on its website[19] for which there is evidence of Russian financing arrangements—Egypt, Finland, and Hungary—and the financing terms for these projects are also listed in this chapter. All told, Rosatom estimates that in 2020 its package of foreign orders exceeded $138 billion in value.

Russia has also had an active domestic build program since 2000, connecting 10 VVERs as well as three non-VVER reactors to its national electrical grid between 2000 and 2021. At the beginning of 2022, Russia had three more VVERs under construction in addition to a fast reactor.

The Russian invasion of Ukraine in February 2022 has heavily impacted international energy commerce, including nuclear energy commerce.[20] For Russian reactor exports, the most immediate (and negative) impacts could be on the projects that have not yet begun construction and are thus more vulnerable to changing political environments and/or sanctions.[21] Nonetheless, these projects are included in the analysis below to illustrate the types of financing offers that Russia has been making to support its reactor exports.

Loans and Equity Investments

Russia has supported its VVER reactor exports with both debt and equity financing. The loan and equity investment details listed below are informed in part by Russian and international news reports, but also by intergovernmental agreements (IGAs) that Russia has signed with its customer countries. These IGAs have been downloaded from Russian government websites (e.g., pravo.gov.ru) as well as Russian legal websites (e.g., cntd.ru[22]). Since the financing terms of Russia's reactor agreements are regularly renegotiated and not necessarily public, it is possible that changes were made to the terms described in this report and that these changes were not posted to the same public websites, publicly reported on by news media, or found as part of the research.

The loan sections of Russian IGAs include details such as total amount of the loan (or at least upper bound, as countries may elect to use less than the specified amount); annual interest rate on the loan (e.g., 3 or 4 percent or a variable rate usually linked to specific international interest rates, possibly with an upper bound to ensure the loan rate does not exceed a certain level); what the loans can be used for, how long repayment is to take and when it begins (e.g., a specified date or whenever the reactors begin producing electricity); how many payments the loan repayment is divided into; provisions that allow for early repayment of the loan; and penalties for late payments. The original financing terms of a given loan may change as a result of later negotiations.

Russian VVERs were connected to electrical grids in three countries (the Czech Republic, Iran, and Ukraine) during the time period considered in this report, but these are not discussed below because the authors could not find the three basic financing details (amount, interest rate, and repayment term) for them in IGAs or news coverage, even if the existence of a loan was hinted at in some news reports.[23] Additionally, the International Atomic Energy Agency (IAEA) lists Russian VVERs as under construction in three countries (Iran, Slovakia, and Ukraine), but again the authors could find neither an IGA nor news reports describing associated Russian financing details.[24] Their absence below is not to imply that Russian loans were not involved; in fact, as alluded to and cited, some news reports did indicate that Russian loans were supplied for these projects.

The financing details of potential VVER projects in Egypt, Finland, and Hungary are also described below, given the presence of IGAs for each, the news coverage of the financing terms in those agreements, the progress of the projects to date, and their listing on Rosatom's website of active projects.[25]

The types of loan offerings that Russia has made to this group of countries as part of its VVER exports are described in greater detail in Appendix 1. In addition to loans, Russia has more recently agreed to make equity investments in some of its reactor export projects, meaning it will receive a share of the cash flows if and when these reactors begin operations and start selling electricity. The details of Russian equity investments in reactor export projects in Turkey and Finland are also described in greater detail in Appendix 1.

Summary

As Table 2 shows, the terms of Russian loans are regularly more generous than what the OECD Arrangement allows. To take just one example, the loan to Egypt seems to be more generous by at least three measures. First, the loan repayment period of 22 years is greater than the maximum of 18 allowed by the OECD. Second, the loan reportedly covers 85 percent of the total project costs, whereas OECD rules allow loans to cover 85 percent of supplier content only and (previous to 2021) no more than 30 percent of local content. Even assuming that Russia was supplying between 50 to 90 percent of the project content—the latter being unlikely at least in markets open to international competition—this would still limit a loan adhering to the OECD rules to between 57.5 and 79.5 percent of the total project cost. Third, there does not appear to be the equivalent of the "exposure fee" or "risk premium" that is required under the OECD Arrangement. For Egypt, EXIM calculates the upfront (one-time) risk premium for a loan to a sovereign entity to be 22 percent.[26] In 2015, when Russia and Egypt agreed to the loan, EXIM interest rates hovered between 3.18 and 3.63 percent—already greater than the reported 3 percent interest rate offered by Russia—and a 22 percent risk premium would raise the de facto interest rate even higher.

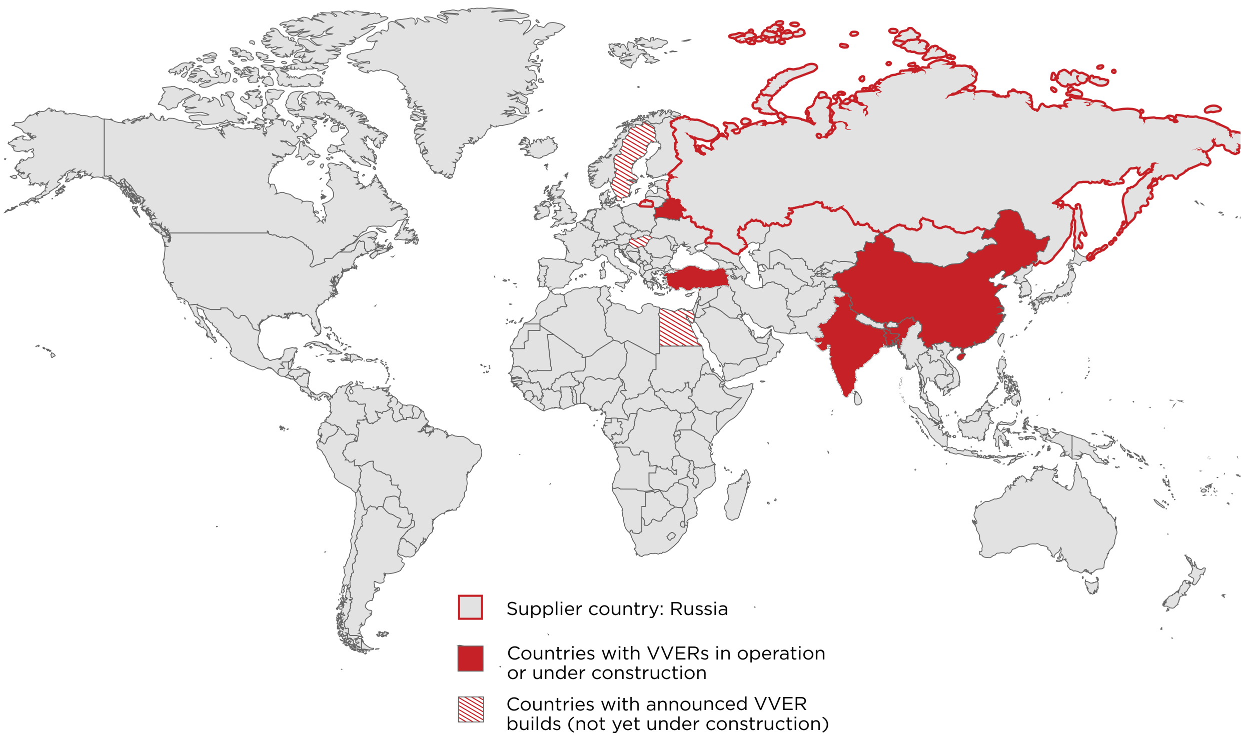
As evidenced by the Finnish and Turkish cases, Russia has also been willing and able to draw on its voluminous state funds to make equity investments in its reactor projects abroad. This is yet another area where private US companies will be challenged to compete with a state-owned entity that is able to draw on billions of dollars in state-funded debt and equity to support its exports. Russia's support of its nuclear exports through both the loan and equity channels has earned it a lengthy list of country customers spanning Europe, Asia, and Africa (see Figure 2).

Russian customers have been relatively close in geographical proximity to Russia, with the reactor site in Egypt being the first one not located in Europe or Asia (see Figure 2).

Table 2: Selected examples of Russian financing terms in support of its reactor exports

Country	Financing terms	Project status
Bangladesh	Loan amount: $11.4 billion Interest rate: London Inter-Bank Offered Rate (LIBOR) six-month + 1.75, but not more than 4 percent Repayment term: 20 years	Rooppur units 1 and 2 are under construction.
Belarus	Loan amount: up to $10 billion Interest rate: revised later to 3.3 percent Repayment term: 15 years	Ostrovets unit 1 is operational; unit 2 is under construction.
China	Loan amount: $1.3 billion Interest rate: 4 percent Repayment term: 13 years	Tianwan units 1 and 2 began operations in 2007.
Egypt	Loan amount: $25 billion Interest rate: 3 percent Repayment term: 22 years	License application to construct submitted in 2021 for El Dabaa units 1, 2, 3, and 4.
Hungary	Loan amount: € 10 billion Interest rate: 3.95 percent, 4.5 percent, 4.8 percent, 4.95 percent Repayment term: originally 21 years, but later revised to 16 years	License application to construct Paks 5 and 6 were submitted in 2020.
India	Loan amount: $3.4 billion Interest rate: 4 percent Repayment term: 14 years	Kudankulam 3 and 4 are under construction and expected to be completed in 2023
Turkey	Equity amount: No less than 51 percent equity investment for >$20 billion project	Akkuyu 1, 2 and 3 are under construction, and unit 4 was granted a construction license in late 2021.
Finland	Equity amount: 34 percent investment stake in an estimated €7–7.5 billion project	The license application to construct Hanhikivi 1 was submitted in 2015, but Finland reversed course in 2022 on account of the invasion of Ukraine.

Figure 2: Russian reactor exports (2000–2021)



Note: Only reactor exports with financing terms identified in this report are included in this map.

Source: Authors' analysis.

CHAPTER 2: FRANCE, CHINA, AND THE REPUBLIC OF KOREA

In term of reactors connected to national grids since 2000 or under construction at the end of 2021, France, China, and the Republic of Korea (ROK) all exported a number of them to customer countries with government-backed financing. This chapter discusses examples from each supplier in turn.

France

France is the strongest nuclear reactor vendor in the European Union; its exports are supported in part by a domestic reactor fleet that provides over 70 percent of France's electricity.[27] The country has been exporting French nuclear reactors since the 1970s.

Since 2000, France has exported its own reactors to China, Finland, and the United Kingdom. In 2002, two French M310 reactors were exported to the Ling Ao site and connected to the Chinese electrical grid. Subsequently, France exported two of its evolutionary pressurized reactor (EPR) designs to the Taishan site. These began construction in 2009 and 2010 and were connected to the Chinese grid in 2018 and 2019, respectively. The first EPR to begin construction was at the Olkiluoto site in Finland in 2005—well before the two projects in China—though it only reached grid connection status in 2022. Finally, two EPRs began construction at the United Kingdom's Hinkley Point site in 2018 and 2019, respectively.

The French entity responsible for the design of both the M310 and the EPR reactors was Framatome. In 2001, this entity merged with Siemens, CEA Industrie, and Cogema to form the AREVA group. This group continued operations until 2015, when it faced bankruptcy in part because of EPR cost overruns. Subsequently, the group's reactor-building division was folded back into Framatome, which is now majority owned by France's state-owned utility, Électricité de France (EDF).[28]

Exports to China

France has played an important part in China's nuclear power program. Before 2000, France exported two of its M310 reactors to the Daya Bay site in China. These were connected to the Chinese grid in 1994 and 1995, respectively. The supply of French M310 reactors provided the basis for China's domestic development of other reactor designs, including the CPR-1000 reactor.[29] China has since developed the Hualong One reactor, which it claims is free of French technology and seems to be the future of Chinese exports (see the next section on China's reactor exports).[30]

Following the connection of two additional M310s at the Ling Ao site, China and France reached a new agreement for two 1750 MWe EPRs to be built at the Taishan site in Guangdong, China. The deal, signed in 2007, stipulated the creation of a joint venture—the Taishan Nuclear Power Joint Venture Company Limited—composed of EDF (30 percent), Guangdong Energy Group (19 percent), and China General Nuclear (51 percent) to execute the project. In other words, the French state-owned EDF took a 30 percent equity position in a project whose contract was reportedly €8 billion.[31] The two EPRs began commercial operations in 2018 and 2019, respectively.

Exports to Finland

In 2005, France began the construction of what was supposed to be the first operating EPR reactor in Finland at the Olkiluoto site, which was already hosting two Russian VVER reactors. The 1600 MWe EPR was to provide up to 14 percent of Finland's electricity.[32]

When construction started in August 2005, the expectation was that operations would commence four years later (2009) and the total cost would be €3 billion. However, the reactor was not connected to the Finnish electrical grid until March 2022,[33] and costs reached at least €11 billion.[34] Given the fixed price nature of the original agreement, the billions of euros in cost overruns meant large losses for AREVA. And although the Finnish entities had a fixed price to shield them in part from those cost increases, the long schedule delays meant that they have had to acquire power from elsewhere in the intervening years despite their investment.

The Olkiluoto 3 EPR financing structure was to be composed of 75 percent debt and 25 percent equity.[35] The French export credit agency Coface provided a loan guarantee covering €570 million of the debt financing. According to a European Commission decision,[36] the loan principal could be drawn over a five-year period and was expected to be repaid over 12 years. The interest rate repayable to the banks involved was variable and indexed to Euribor. Coface charged a fee of 2.5–3.5 percent for each payment as a premium. France notified the participants of the guarantee in the Arrangement on Officially Supported Export Credits concluded within the OECD in 2003, and the transaction was not challenged by any of the participants to the OECD Arrangement.[37]

Exports to the United Kingdom

Two EPR units are also under construction in Somerset, England. Together, these reactors are referred to as the Hinkley Point C nuclear power station and have a nameplate capacity of 3,200 MWe. EDF's plans to build the two 1600 Mwe reactors at Hinkley Point solidified in 2008 when it purchased British Energy at £12.5 billion.[38] Construction began in 2018, and the plant is scheduled to begin operations in 2026. In 2016, the cost of the project was estimated to be £18 billion.[39] This estimate has grown over time, however, and as of May 2021, it had reached between £22 billion and £23 billion.[40]

The financing structure of the two EPR projects is 100 percent equity—EDF contributes 66.5 percent of the project costs, and China General Nuclear Power Corporation (CGN) invests the remaining 33.5 percent.[41]

As part of a 2015 agreement, EDF and the UK agreed on a "contract for differences" approach that ensures a fixed level of revenue for the EPR project by setting a fixed price level—or "strike price"—on the electricity produced by Hinkley Point C and sold on the market. If the actual market price is lower than this price, the UK will pay the project owners the difference. Similarly, if the market price is higher than the strike price, the Hinkley Point C owners will pay the UK the difference. Specified in the contract, the strike price is £92.50 per MWh and will last for 35 years from initial operation of the plant.

China

To date, China has exported nuclear power reactors to only one country: Pakistan. In 1991, China announced a plan to export its first reactor to Pakistan's Chashma Nuclear Power Plant (CHASNUPP 1). By the end of 2021, Chinese exports to Pakistan consisted of four operating reactors at the Chashma site, with an additional reactor (CHASNUPP 5) planned, and one operating reactor and another under construction at the Karachi site (referred to as KANUPP 2 and 3). The Export-Import Bank of China (CHEXIM) has provided debt financing in support of Chinese exports, including for nuclear power projects abroad. In the latter case, CHEXIM can utilize "nonconcessional" loans with interest rates comparable to the market rate and provided in USD, or "preferential" loans where the Chinese government subsidizes the loan to provide a lower interest rate.[42]

China has also participated in the financing of reactor projects outside of Pakistan, though not using Chinese reactors. As mentioned previously, China General Nuclear has a 33.5 percent stake in the two EPR reactors being built in the United Kingdom. China initially had a 20 percent share in the development of two EPRs at the Sizewell site and a 66.5 percent share in the development of two of its own Hualong One reactors at the Bradwell site.[43] However, Chinese involvement in any British reactor projects beyond Hinkley Point has been thrown into question since the UK government hardened its stance toward China in 2021 on account of security issues.[44]

In February 2022, China announced a joint contracting plan with Argentina to build a Chinese Hualong One reactor at Argentina's Atucha site, which would be the first export of a Chinese reactor beyond Pakistan. China has reportedly offered large loans (approximately 85 percent of the total project cost) to support the $8 billion project.[45]

Details on China's financing of projects in Pakistan, the United Kingdom, and Argentina can be found in Appendix 2.

Expanded Chinese nuclear exports with government-backed financing would fit with China's larger export trends. The country launched its One Belt One Road Initiative (OBOR) or Belt and Road Initiative (B&R) in 2013, which has involved a collection of development and investment initiatives from East Asia to Europe in an effort to expand China's economic and political influence.[46] Total Chinese investments in this initiative, including loans to support infrastructure projects such as power plants, could reach more than $1 trillion by 2027.[47] In 2019, one Chinese official estimated that "Belt and Road" nuclear projects could earn Chinese firms $145 billion by 2030, and that 41 "Belt and Road" countries were already operating nuclear energy programs or in the process of planning them.[48] A senior Chinese Communist Party member suggested that China could build 30 new reactors overseas by 2030 in Belt and Road countries.[49]

Republic of Korea

Compared with the other suppliers discussed in this report, the ROK is a relative newcomer to reactor exports. In 2009, it won its first export contract to deliver four APR1400 reactors to the Barakah site in the United Arab Emirates (UAE). The ROK-led consortium beat out a US-Japanese consortium that would have built advanced boiling water reactors and a French consortium that would have built EPRs.[50] Unit 1 began construction in 2012 and was connected to the UAE grid in 2020; unit 2 began construction in 2013 and was connected to the UAE grid in 2021; and units 3 and 4 began construction in 2014 and 2015, respectively.

According to news reporting at the time, the Korean group's bid may have been $16 billion lower than that of the French group.[51] Initially, the financing arrangement was reported to involve $10 billion from the Export-Import Bank of Korea (KEXIM) and $2 billion from the US EXIM Bank.[52] Ultimately, however, the state-owned Korea Electric Power Company (KEPCO) and the Emirates Nuclear Energy Corporation (ENEC) finalized a financial agreement in 2016 to support the project. The total amount of financing was estimated to be $24.4 billion with $19.6 billion in direct loan agreements and $4.7 billion in equity commitments (i.e., 80 percent debt and 20 percent equity). The $19.6 billion in debt was broken down as follows:[53]

- Department of Finance of Abu Dhabi: up to $16.2 billion
- KEXIM: $2.5 billion (KEXIM's portion of the financing is reportedly on an 18-year repayment period once construction is completed[54])
- Local and international commercial banks, including the National Bank of Abu Dhabi, the First Gulf Bank, HSBC, and Standard Chartered: a $250 million commercial tranche

The remaining $4.7 billion is made up of equity commitments from ENEC (82 percent) and KEPCO (18 percent). In other words, the ROK is dedicating nearly a billion dollars of equity investment to the project.[55]

Summary

The three supplier countries beyond Russia that are in competition with the United States have all made state-backed financing offers in support of their reactor exports (see Table 3). These countries have exported their reactors to Europe, Asia, the Middle East, and (potentially) South America (see Figure 3).

Table 3: Examples of state-supported financing offers from France, China, and the ROK in support of their reactor exports

Supplier country	Customer country	Financing terms from the supplier country
France	China	Taishan 1 & 2: 30 percent equity investment in the project, estimated to cost €8 billion
France	Finland	Olkiluoto 3: Coface loan guarantee covering €570 million to be re-paid over 12 years
France	UK	Hinkley Point C: 66.5 percent equity investment into a £22 billion to £23 billion project (the other 33.5 percent is coming from China)

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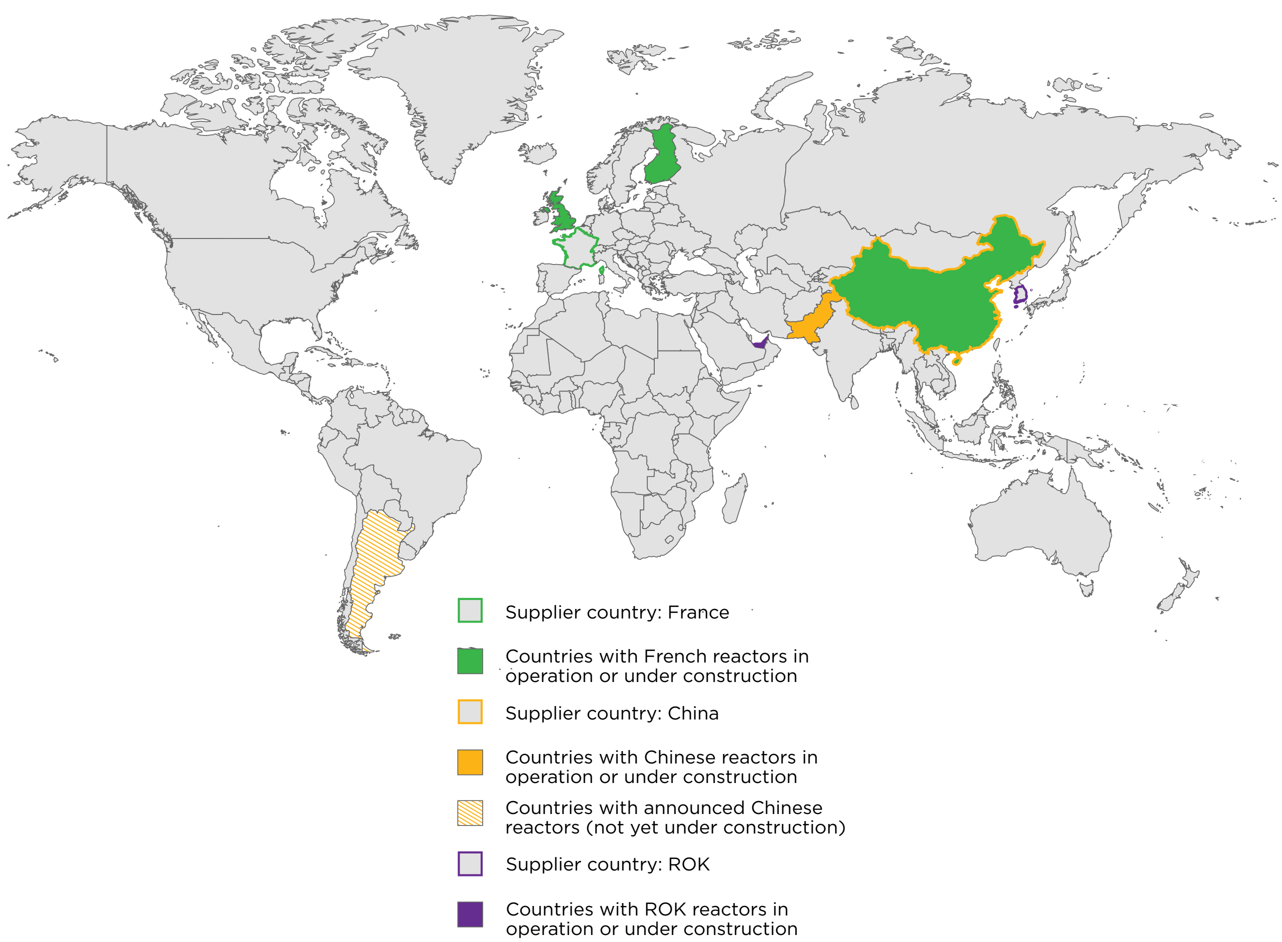
Supplier country	Customer country	Financing terms from the supplier country
China	Pakistan	CHASNUPP 3 & 4: Three 20-year loans: $1 billion loan at a 2 percent interest rate; $474 million at a 6 percent interest rate; $108 million at a 1 percent interest rate. KANUPP 2 & 3: Three 20-year loans for KANUPP 2 & 3: $4 billion at a 2 percent interest rate; $2.27 billion at a 6 percent interest rate; $429 million at a 1 percent interest rate.
China	Argentina	Atucha 3: (based on earlier reporting) one $6.7 billion loan at a 4.5 percent interest rate with a 20-year repayment term
Republic of Korea	United Arab Emirates	Barakah 1, 2, 3, & 4: KEXIM provided a loan of $2.5 billion with a repayment term of 18 years; state-owned KEPCO has an 18 percent stake in the $4.7 billion equity investment.

Figure 3: French, Chinese, and ROK reactor exports (2000–2021)



Note: Only reactor exports with financing terms identified in this report are included in this map.

Source: Authors' analysis.

France's initial export of an EPR reactor to Finland was supported by debt guaranteed by Coface, the official French export credit agency at the time. For the more recent EPR exports to China and the United Kingdom, the state-owned utility EDF has brought billions of dollars in equity investment—the type of financing that is not constrained by the OECD Arrangement. This financial capability comes from EDF's size; at €80 billion in sales in 2021 and total assets of over €360 billion, it is one of the largest utilities in the world.[56]

Similar to the Russian loans discussed in the previous chapter, China's loans to Pakistan and (reportedly) Argentina from state-owned banks would appear to be more generous than what the OECD Arrangement allows in terms of longer repayment periods, greater coverage of imported and local content, and lower interest rates (or no apparent risk premium). By comparison, for US loans to both Argentina and Pakistan, EXIM would apply an exposure fee of 41 percent for an 18-year loan to a sovereign entity, which would raise the cost of the loan substantially. If the proposed Chinese loan to Argentina actually covers 85 percent of the project's cost, that by itself would appear to be more generous than what the OECD Arrangement permits. Finally, if the Chinese loans include 20-year repayment terms, these likewise appear to be more generous than what the OECD Arrangement permits.

The ROK's APR1400 exports to the UAE are supported by KEXIM as well as equity investments from the large Korean utility company KEPCO, which is majority owned by the ROK government. KEPCO is the largest utility in the ROK with revenues of over $50 billion and assets approaching $180 billion in 2021, enabling it to make these types of large investments in support of its exports.[57] In 2022, the new ROK government established new and higher goals for increasing domestic use of nuclear energy and building new reactors.[58]

CHAPTER 3: THE UNITED STATES

Compared to state-owned reactor vendors in Russia, China, France, and the ROK, advanced reactor companies in the United States are smaller private entities. Westinghouse Electric Corporation, for example, may be able to supply nuclear power plant designs, components, and materials to another country, but the company itself does not have the financial strength to offer billions of dollars in loans or make comparable equity investment to support reactor construction. Governments also have different motivations for making investments compared to private companies and may prioritize interests other than profits. Although the US government does include agencies—in particular the Export-Import Bank of the United States (EXIM) and the relatively new International Development Finance Corporation (DFC)—that could provide financing assistance in support of US reactor exports, such support has not been provided in recent decades.

This chapter therefore examines the history of EXIM support for US reactor exports. It begins with EXIM's early financing offers during the 1950s–1970s, when the bank played an important role in the US government's Atoms for Peace program. These early offers forged nuclear energy relationships that in some cases still exist today, just as new civil nuclear energy programs started in the next decade may be ongoing in a half century or more. The chapter then turns to the rise of international reactor supply competition and the OECD Arrangement on export credits for reactor supply to which it led, as well as a cautionary tale from an EXIM-financed reactor project in the Philippines that never produced any electricity. It concludes with recent developments that are relevant to US reactor export financing policy discussions.

Federal Financing of Exports: EXIM Bank and the DFC

As mentioned previously, two federal entities involved in financing overseas projects could support US reactor exports in the future:

> Export-Import Bank. EXIM is an independent executive branch agency that functions as the official US export credit agency. EXIM supports the export of US goods and services by providing a variety of financial services. The two that have been the most important to reactor exports in the past (described in the next section) are direct loans—where EXIM loans money to a foreign entity for a given project—and loan guarantees, where the bank guarantees that a private bank will get a percentage of its loan back.[59] The volume of financing that EXIM provides on an annual basis is large. For example, for the fiscal year that ended on September 30, 2021, EXIM authorized $5.8 billion in loan guarantees, insurance, and direct loans in support of $9.2 billion in US export sales.[60] Nonetheless, the bank has nearly 70 percent of its statutory limit on lending ($135 billion) unobligated.[61] As discussed later, in recent decades EXIM has supported the export of other large energy projects.

International Development Finance Corporation. In 2018, Congress passed the Better Utilization of Investments Leading to Development Act (BUILD Act), which consolidated US development finance efforts previously carried out in large part by the Overseas Private Investment Corporation (OPIC) and elements of the US Agency for International Development through the creation of the DFC. The DFC carried forward much of OPIC's authority and role. Unlike its predecessor, though, it was authorized to make equity investments in foreign projects. It also had a spending cap of $60 billion, compared to OPIC's cap of $29 billion.[62] The DFC initially carried forward OPIC's legacy prohibition on support of nuclear power projects, but in 2020 it announced that it was eliminating this prohibition.[63] Presently, the DFC has over $37 billion in total active projects across the world. Though it has committed to reaching net-zero emissions in its portfolio by 2040, it has not yet approved any nuclear projects.[64]

Since 2000, the only US reactor exports have been four Westinghouse AP1000s to China.[65] In 2005, EXIM did approve a preliminary commitment request from Westinghouse Electric Corporation for a combination of guaranteed and/or direct loans of up to almost $5 billion to support those export sales.[66] In the end, however, no loans from EXIM were used for the builds in China.[67]

Historical EXIM Bank Support for American Reactor Exports

While it has not played a role in US reactor exports in recent decades, EXIM played an integral role in supporting the United States as the leading exporter of reactors in the 1950s–1970s (see Appendix 3).

The reactor exports listed in Table 4 and depicted in Figure 4 were not the sum total of US reactor exports during this period. Some reactor exports did not have loans from EXIM to support their construction, though in certain cases they did have financing from other federal entities (e.g., the GE boiling water reactors [BWR] at the Tarapur site in India were supported by a loan from the United States Agency for International Development[68]). In some cases, EXIM later added additional financing to support the same project (i.e., subsequent loans or loan increases) or provided a guarantee on project financing loans from private banks.

Table 4: First EXIM loans in support of US power reactor exports to a country or region

Year of first credit	Customer country	Loan amount (million $)	Interest rate	Repayment term (years)	Reactor designs and notes
1959	Euratom	135.0	4.5 percent	20	Westinghouse pressurized water reactors (PWRs) and GE BWRs
1959	Italy	34.0	5.25 percent	15.5	Westinghouse PWR
1964	Spain	24.5	5.5 percent	15	Westinghouse PWR

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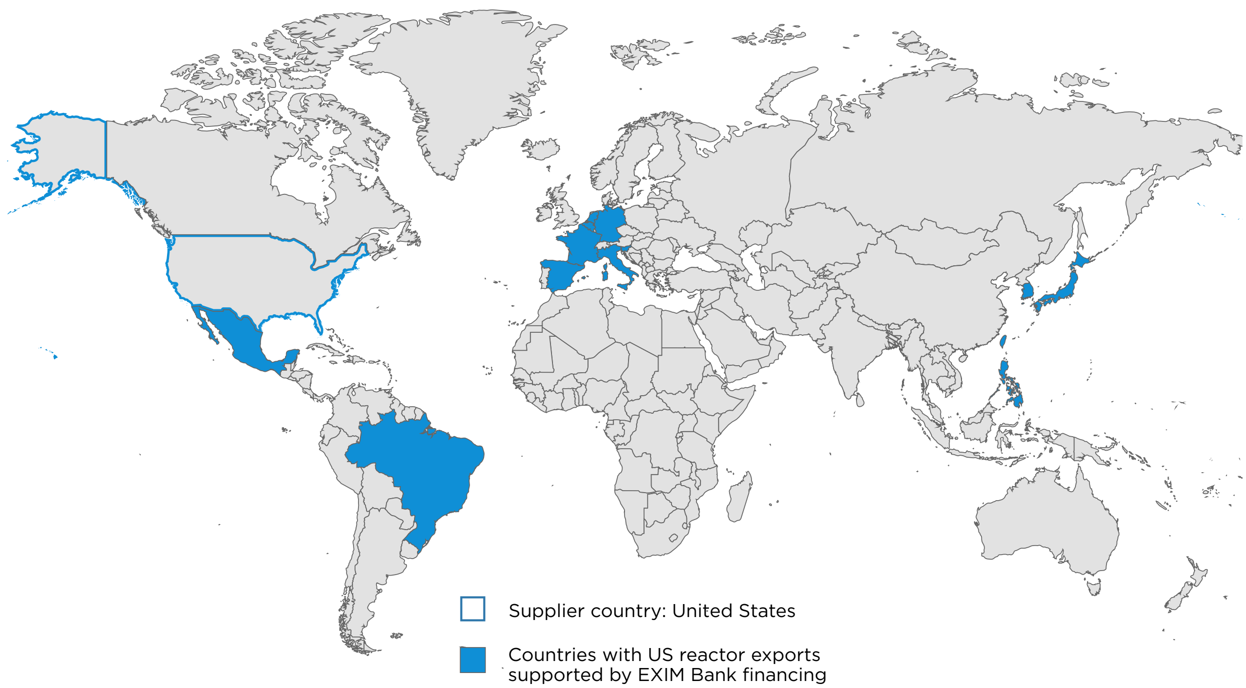
Year of first credit	Customer country	Loan amount (million $)	Interest rate	Repayment term (years)	Reactor designs and notes
1966	Japan	25.2	5.5 percent	16	GE BWR
1969	Taiwan	62.6	6 percent	15	GE BWR
1969	ROK	47.3	6 percent	14	Westinghouse PWR
1972	Brazil	138.0	6 percent	15	Westinghouse PWR
1972	Mexico	54.2	6 percent	10	GE BWR;
1974	Yugoslavia	156.2	7 percent	10	Westinghouse PWR; today, this reactor is in Slovenia
1976	Philippines	244.9	8.5 percent	2.5	Westinghouse PWR; loan repayment was to begin in 1992

Note: Loan amounts are as they appear in the EXIM documents cited for the year in the table (i.e., they have not been converted to constant 2022$ or any other constant year$). Not all loans listed in annual reports appear in press releases, and there is typically greater detail on loan and project terms in press releases. The 1974 annual report does not list any individual loans made during that fiscal year. The increasing rates shown were a function of higher interest rate environments.

Source: EXIM Bank annual and semiannual reports; EXIM Bank press releases.[69]

The loan amounts in Table 4 are, again, only initial loans and collectively a small piece of EXIM's support for US reactor construction abroad during this period. In 1973, EXIM estimated that since the 1950s it had provided $3 billion (involving around 49 individual credits) in support of the sale of US equipment and services for nuclear power development throughout the world.[70] The 1970s saw the largest amount of EXIM loans and guarantees for nuclear power exports in terms of dollars; EXIM later calculated that during the 1970s alone it authorized $4.2 billion in direct credits and $2 billion in financial guarantees.[71] The agency's 1979 annual report, in particular, mentions that a $936.3 million credit to the Korea Electric Company to assist with $1.1 billion in US exports for two nuclear power plants was its "largest credit ever issued."[72]

Figure 4: US reactor exports (1959–1976)



Note: Only reactor exports with EXIM Bank financing terms identified in this report are included in this map.

Source: Authors' analysis.

Of the EXIM loans listed in Table 4, the credits to the Philippines in the 1970s are the most conspicuous for their odd repayment structure, with repayment beginning nearly 16 years after the loan was announced and the repayment term only 2.5 years. Separate from the EXIM financing details, the project had a controversial history; while the Westinghouse-designed reactor was completed at the Bataan site in 1984 (at a cost several times its originally estimated budget), the Philippines national government decided not to operate it due to safety concerns raised in the years following the project's announcement, even before the Chernobyl accident in 1986 amplified safety concerns over nuclear power in general.[73]

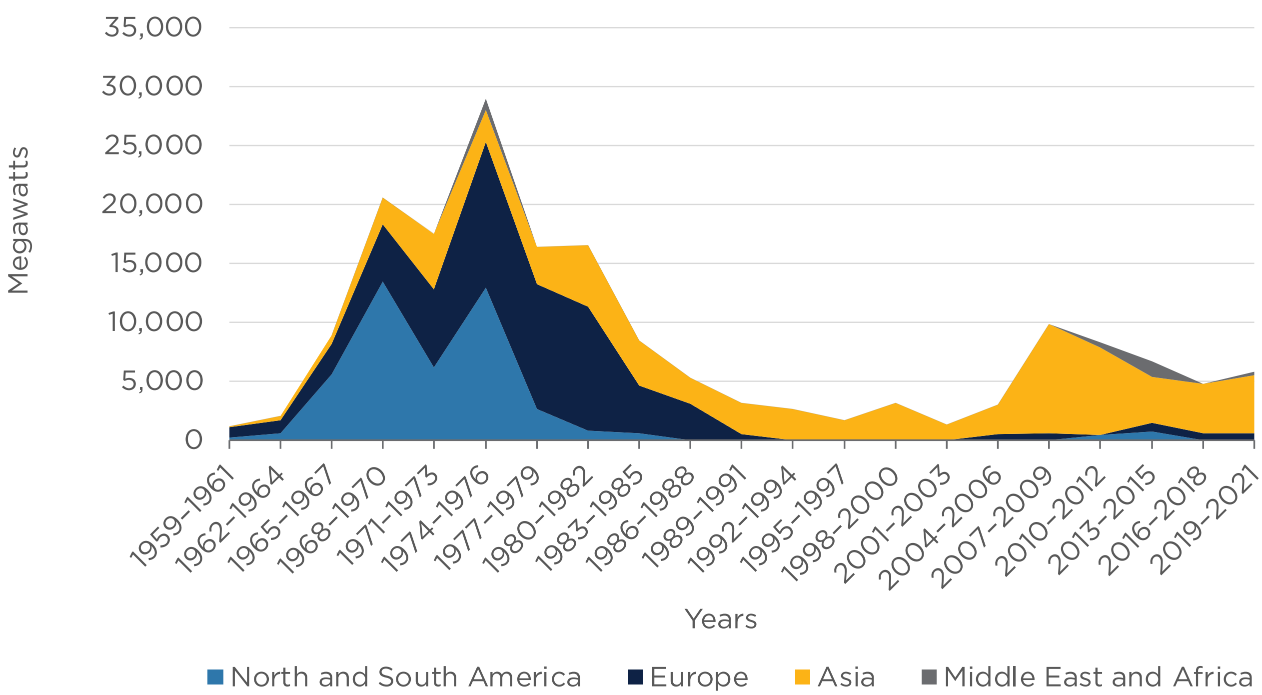
The project was also subject to accusations of corruption and bribery in the selection of Westinghouse and the consortium to build the reactor.[74] The original contract was signed during the Marcos government in 1976. The later Aquino government charged that the selection process had been corrupt and sought to find a way out of the loans extended by EXIM.[75] Litigation over the project began in 1988, and the Philippines and Westinghouse finally reached a settlement agreement in 1995.[76] In the end, the reactor project in the Philippines was the only export identified in this report as being supported by EXIM to never generate any electricity while also adding substantially to the debt of the consumer country. (The Philippines finally paid off the loan in 2007.[77])

The Philippines project was a cautionary tale of how US nuclear reactor exports could go wrong. But by the time of its development in the late 1970s and into the early 1980s, the US nuclear industry was already facing an array of broader challenges. To begin with, competition in the reactor supply arena had been growing. EXIM's 1974 annual report tallied 37 power reactors in 11 countries that the bank had financed that year but noted vigorous competition from Germany, Canada, and the Soviet Union; it also stated that the bank was expecting French, Japanese, British, and Swedish competitors to enter the export market soon.[78] In 1975, the bank assessed that while the United States had previously captured nearly 100 percent of the non-Communist market between 1955 and 1965, that share had fallen to 60 percent by 1974 and was projected to decline further in the second half of the 1970s.[79]

In the early 1980s, US companies were complaining that their competitors were winning reactor bids not on the basis of superior technology but on that of superior financing offers.[80] In part as a result of the increased competition, in 1984 OECD countries reached a sector understanding on export credits for nuclear power plants that was intended to help level the playing field.[81]

Other challenges to the US nuclear industry included delays in US reactor construction schedules, cost overruns, and rising safety concerns stemming from the Three Mile Island accident in 1979 and the Chernobyl disaster in 1986, which lowered public support and utility interest in nuclear projects in general.

Figure 5: Net capacity of reactor construction started each year, averaged over three-year periods (1959–2021)



Source: IAEA PRIS.

As Figure 5 illustrates, new reactor construction starts in the United States were already dwindling toward the end of the 1970s, followed soon after by a decrease in new construction starts in Europe. Globally, new reactor construction declined in general by the end of the 1980s—shrinking the size of the market for which US companies could compete—and shifted from the United States and Europe to Asia. (The new builds in Asia have been driven mainly in recent years by the large reactor construction program in China.) All told, there does not appear to be an example of EXIM providing financing in support of a US reactor export to a new country since the 1970s. A 1991 EXIM report noted that in general, "Over the last ten years, there have been very few authorizations involving nuclear power projects."[82]

While EXIM has not financed a new US reactor export in recent decades, it has recently approved loans for projects—including power plants—abroad of a similar scale (over a billion dollars). For example, EXIM extended $4.8 billion for liquefied natural gas (LNG) projects in Australia in 2012[83]; $5 billion for a petrochemical project in Saudi Arabia in 2012[84]; and $4.7 billion for an LNG project in Mozambique in 2019.[85] At the least, these examples demonstrate the bank's ability to provide financing at a scale comparable to, for example, what the KEXIM supplied in support of the APR1400 exports to the UAE, as discussed in chapter two.

Recent Policy Developments

Over the past four years, the US government has taken some steps to broadly—i.e., not specific to nuclear energy—level the competitive playing field with respect to China's export ambitions (and potentially Russia's). In 2019, EXIM was reauthorized,[86] and in Section 402 of that reauthorization, Congress directed EXIM to establish a "Program on China and Transformational Exports." One purpose of this program is to support loans and guarantees at rates and terms that are competitive with those offered by China or "a covered country" to neutralize competing official export credits from such parties. The legislation also sought to advance US leadership with respect to China and support innovation through direct exports in several areas, including renewable energy, energy efficiency, and energy storage.

A "covered country" was defined by Congress as any country that 1) the secretary of treasury designated in reports to specific congressional committees; 2) is not a participant to the OECD Arrangement on officially supported export credits; and 3) is not in substantial compliance with the financial terms and conditions of the aforementioned OECD Arrangement. Bipartisan legislation introduced in March 2022[87] identifies Russia specifically as a "covered country" under the EXIM program and adds civil nuclear energy to the explicitly listed areas of support.

Similar to the EXIM reauthorization in 2019, one of the main policy drivers behind the BUILD Act, which created the DFC in 2018, was responding to China's Belt and Road Initiative. Among its many activities, the new DFC has supplied financing assistance for energy-related projects of a scale comparable to a nuclear power plant. For example, in 2021 the DFC provided a $217 million loan to support construction of a natural gas plant in Sierra Leone[88] and a $500 million loan to India for a thin-film solar module manufacturing facility[89]; in 2020, it provided an up to $200 million loan to finance a 420 MW natural gas power plant in Mozambique.[90]

While the DFC has made equity investments in companies and funds abroad, these are on a significantly smaller scale than the equity investments in nuclear projects discussed in the last two chapters. Indicatively, the DFC's largest equity investment in 2021 was only $30 million.[91] However, in several cases the DFC has supported equity investment funds at the level of a hundred million dollars or more.[92] In combination with matching (or greater) private equity funds, this could begin to approach the scale of the Korean equity investment in the UAE APR1400 projects, though not that of the French equity investments in the United Kingdom and China EPR projects or that of the Russian equity investments in Finland and Turkey.

With respect to nuclear power, EXIM and DFC have recently indicated interest in supporting reactor exports through nonbinding memoranda of understanding and letters of intent. In 2020, the DFC signed a letter of intent to support the American advanced reactor company NuScale Power to develop 2,500 MW of nuclear energy in South Africa,[93] and the US government signed an intergovernmental agreement with Poland regarding a potential new civil nuclear energy program. The latter agreement stated that the US government had a "strong interest in facilitating the utilization of the EXIM and other applicable and available US financing institutions to support the overall financing for the Program."[94] Later that year, EXIM also signed a memorandum of understanding with Poland's ministry of climate and environment to carry out "nuclear, clean, and strategic energy projects" in that country.[95] Following the intergovernmental agreement entering into force in February 2021, press reports indicated a strong expectation among Polish officials that the US would provide financing to support any US reactor builds in Poland.[96]

During the same year, Special Presidential Envoy for Climate John Kerry and Romanian President Klaus Iohannis announced Romania's intent to build NuScale Power's small modular reactor (SMR) as part of efforts to address the climate crisis.[97] EXIM has signed a memorandum of understanding with Romania to explore and identify options to potentially use EXIM financing in a total aggregate amount of up to $7 billion, which could support nonnuclear and nuclear projects, including SMRs.[98]

Summary

After early US dominance in reactor supply, other countries closed the technology gap with the United States and produced viable alternative reactor suppliers. In addition, government-backed financing terms became an increasingly important competitive factor. The EXIM financing of US reactor exports in the 1960s and 1970s led to commercial relationships that have continued to the present day—decades after the loans were paid back. Investments like the Philippines reactor project, however, offer a cautionary tale of how such endeavors can go badly.

The AP1000 projects in China are the only examples of US reactor exports in recent decades; they are also the only recent nuclear project where a customer country elected not to use financing from a supplier country, even though EXIM was prepared to assist on some level with $5 billion in debt. Although government-backed financing from the supplier country was not decisive in this case, it has proven to be a key factor in the broader marketplace of international reactor supply. China's economic strength and strategic motivations for importing the most advanced reactor technologies in the world from the United States (as well as France and Russia) will almost certainly not be replicated in other cases.

Other countries currently in discussion with the United States to deploy either AP1000s or NuScale plants (Poland and Romania) have expressed their interest in and expectation of financing support from the US government in order to move forward with the associated project. It will be difficult for private US companies to make the kind of financing offers that the large, state-owned entities described in chapters one and two can extend. Westinghouse, for instance, was bought for $4.6 billion in 2018 and in 2020 had earnings of $650 million—nowhere near the financial size of its foreign competitors.[99]

The US government was already concerned with growing Chinese influence in the world and had taken initial steps to enable EXIM and DFC to match export offers from China. The OECD Arrangement does have provisions (e.g., Article 45) for participants to match an offer from a country that is outside the arrangement, but businesses have reported that the implementation of this provision is difficult to follow in practice.[100] The Russian invasion of Ukraine in 2022 has heightened US government efforts to limit Russian influence in general, including by responding more strenuously to Russia's export ambitions. Neither China nor Russia is committed to the OECD Arrangement on export credits that applies to nuclear power plant supply, and there have been congressional proposals to encourage EXIM to better compete with both countries' exports, including reactors.

CHAPTER 4: CONCLUSIONS

As the examples collected in this report demonstrate, government-backed financing for reactor exports is a standard component of international nuclear energy commerce. For large, capital-intensive projects such as nuclear power plants, multiple sources of funding are helpful for distributing the associated financial strain, and sources of lower-interest financing improve the economics. Separately, reactor construction and operation take place over multiple decades, and the governments of customer countries want those of supplier countries to have an ongoing stake and interest in a project's success. Additionally, the construction time period for a reactor project can span multiple political administration cycles in both the supplier and customer countries, making sustained political support particularly important. For all of these reasons, it is unsurprising that the governments from the state-owned reactor vendors in Russia, China, France, and the ROK have all provided financing to support their reactor exports in the last two decades.

Russia has been offering particularly attractive financing options to support its nuclear exports, which partly explains why it is currently the world's leading supplier of reactors. The terms of Russian loans for these projects have been more generous than what the OECD Arrangement allows for its members. Even if the US government was willing to depart from OECD rules when presented with clear evidence that the Russian loans are more generous, the details of those loans may only become public after a customer country has made a selection, meaning the United States would likely have already lost the sale. The Russian government has also been willing to offer billions in equity investment to support its VVER projects overseas—an offer that comparatively smaller, private US entities are unlikely to be able to match.

With the largest national nuclear reactor build program underway anywhere in the world, China appears to be planning to pivot to exporting the same designs in the coming decades. (By contrast, the United States will soon—nominally in a year or two—have zero reactors under construction after the badly delayed and over-budget AP1000s at the Vogtle site are completed.) Chinese reactor vendors are able to point to a robust domestic infrastructure as a result of China's build program, and the country has clearly demonstrated the capability to make loan offers that are more generous than what the OECD Arrangement permits, such as those it reportedly made to Pakistan and Argentina. The billions of dollars in equity investment that China General Nuclear is dedicating to the EPRs at Hinkley Point are further examples of financing strength that private US vendors are unlikely to be able to match.

Even in the case of countries that wish to pursue nuclear projects but not with Russian and Chinese companies for geopolitical reasons—especially after the Russian invasion of Ukraine—the United States will still face strong competition from friendly nations. France and the ROK are both members of the OECD and thus bound to respect the OECD Arrangement on export credits, but private US reactor vendor companies are still nowhere near the size of state-owned entities such as EDF and KEPCO. For this reason, they will struggle by themselves to match the type of equity offers—which are not restricted by the OECD Arrangement—that those huge utilities have made in the past to support their exports. The ROK will also benefit from a demonstrated capability to deliver reactor projects—the APR1400s that KEPCO built in the ROK as well as those constructed in the UAE—better than the United States or France. For the US to compete with these countries, government-assisted financing will be crucial, in addition to other factors such as better project management and delivery. Reactors that could be purchased in smaller increments of capital to reduce overall financial strain, have lower overnight costs, or have designs that can serve other missions such as providing process heat for industrial applications would help to garner greater customer appeal.

As other countries potentially move forward with civil nuclear energy programs, the US government will need to make a decision as to whether it will assist in financing US reactor exports. The federal government has a variety of potential rationales for doing so: supporting American jobs, assisting other countries' decarbonization efforts and confronting the broader problem of climate change, reducing other countries' fossil fuel dependencies for geopolitical reasons, limiting Chinese and Russian influence in general, and the national security value in the United States having some role in international nuclear reactor commerce.[101] On the other hand, EXIM or DFC financing will come with financial risk and, as the Philippines reactor project debacles shows, some individual projects may not lead to success.

Given the breadth of US interests in and the stakes of potential US reactor exports, the White House National Security Council should convene meetings on the issue with attendance from the federal entities with financing authority—EXIM and DFC—as well as other agencies involved in civil nuclear energy policymaking. These meetings should review the possibilities in the near and long term for US reactor exports, the importance of federal financing and other government support mechanisms in determining selection outcomes, and how US interests are affected by these outcomes.

The Russian invasion of Ukraine has increased efforts to limit Russian influence, including through its exports. Given that both Russia and China exist outside of the OECD export credit arrangement, Congress should ensure that EXIM in particular can effectively match offers from both countries in its transformational exports program. In addition, as the International Energy Agency and other organizations have outlined,[102] transforming the global energy sector to avoid the worst outcomes of climate change will involve a portfolio of low-carbon energy technologies. If the US wants to put even greater emphasis on addressing climate change and better compete with China and Russia in the reactor export arena, it should expand the focus of the EXIM transformational exports program beyond renewable energy to include all low-carbon energy technologies, including nuclear reactor facilities.

Finally, the US government does not need to be the only national government providing financing in support of US reactor exports. Given that some content in any US reactor export will likely come from US allies, the latter could provide financing to support that content.[103] In general, the US government could look for ways to strengthen nuclear energy cooperation between the United States and its allies to aid competitiveness against Russia and China.[104]

APPENDIX 1: DETAILS OF RUSSIAN FINANCING FOR REACTOR EXPORTS

Loans

Bangladesh

IGA details: A 2016 Russia-Bangladesh IGA describes terms for a loan to finance works, services, and equipment supplies for the construction of the Rooppur nuclear power plant in the amount of "up to US $11.38 billion."[105] According to the terms of the agreement, the loan can finance up to 90 percent of the value of each contract for the performance of work, the provisioning of services, and the supply of [specified] equipment. The IGA states that the loan must be used by Bangladesh between 2017 and 2024, with a repayment term of 20 years and a requirement of two payments on the loan each year starting in March 2027. The interest rate on the loan is the LIBOR six-month rate added to 1.75 percent per year, but cannot be more than 4 percent per annum. (If the LIBOR rate is negative, it is considered to be zero.)

News reporting: At the time of the IGA's signing, the Russian news agency TASS reported that the loan amount was $11.38 billion, that it would be used between 2017 and 2024, and that the loan repayment term was 20 years (with six-month payment intervals).[106]

Project status: Construction on Rooppur units 1 and 2 began in November 2017 and July 2018, respectively; the two units are expected to begin operations in 2023 and 2024, respectively.[107] Both will be VVER-1200 reactors with outputs of 1200 MWe.

Belarus

IGA details: A 2011 IGA, amended as recently as 2020, between Russia and Belarus stipulates that Russia will supply Belarus with a state export credit of up to $10 billion to finance 90 percent of the value of each contract between Atomstroyexport (from the Russian Federation) and the state institution in Belarus for the supply of goods, the performance of work, and the provision of services supplied, performed, and rendered by Atomstroyexport for the construction of two nuclear power reactors. Originally, the loan was to be used by Belarus between 2011 and 2020, with repayment over 15 years beginning six months from the date the nuclear power plant was commissioned, but no later than April 1, 2021. Interest on the loan was to be calculated on 50 percent of the amount of each used portion of the loan at the rate of 5.23 percent per annum. The remaining 50 percent of each used portion of the loan was to bear interest at LIBOR for six-month US dollar deposits, increased by a margin of 1.83 percent per annum.[108]

In 2020, Russia and Belarus agreed to modify the original terms of the loan so that the loan could be used as late as 2022, with repayment beginning no later than April 1, 2023, and the interest on the whole loan was fixed at 3.3 percent.[109]

News reporting: TASS reported in 2011 that Russia would provide up to $10 billion to Belarus with a "ten-year takedown period" and a 15-year repayment period.[110] Nuclear Engineering

International then reported in 2020 that the loan repayment was to begin no later than April 1, 2021, at an interest rate of 5.23 percent per year for half of the funds and a six-month LIBOR plus 1.83 percent per annum for the other half.[111]

Regarding the amended loan agreement, Nuclear Engineering International reported in 2021 that the loan terms had been amended to extend the period of use by two years, to lower/raise the interest rate on the loan to 3.3 percent per year, and to delay the start of the repayment period until 2023.[112] Belarus had asked for the restructuring in part to account for the delay in commissioning the two reactors.

Project status: Construction on Ostrovets units 1 and 2 began in 2013 and 2014, respectively. Unit 1 began commercial operations in 2021, and unit 2 is expected to do so in 2022.

China

IGA details: A 1992 IGA stipulated that Russia would provide a state loan of up to $2.5 billion to China at an interest rate of 4 percent to support the construction of two VVER reactors.[113] In 2010, the two countries agreed on a protocol to the 1992 agreement acknowledging the remaining Chinese debt from the loan and stating that the Chinese party would repay the used amounts over the following 13 years.[114] In 2016, an addendum to the agreement was reached regarding terms for early repayment of the loan by China.[115]

News reporting: According to a 2003 article in the Nonproliferation Review, the initial Russian loan to China was for $1.3 billion with an interest rate of 4 percent.[116] In 2010, the Russian federal assembly announced that it had ratified a protocol to the 1992 agreement, explaining that repayment would now take a monetary rather than commodity form and that as of October 1, 2010, the amount of China's debt to Russia was $1,298,960,000.[117] Nuclear Engineering International reported in 2016 that China repaid the rest of the $1.3 billion loan ahead of schedule.[118]

Project status: Tianwan units 1 and 2 began operations in 2007 and two more Russian VVER reactors—units 3 and 4—were connected to the Chinese electrical grid at the same site in 2017 and 2018, respectively. China is planning to build two additional VVERs at the Tianwan site, as well as two others at the Xudabao site.[119]

Egypt

IGA details: A 2015 Russia-Egypt IGA stipulates cooperation in the construction and operation of a four-unit nuclear power plant based on Russian PWRs of up to 1.2 GW each as well as seawater desalination units at each power unit.[120] The agreement emphasizes that its conclusion and execution is contingent upon a separate financing agreement.[121]

News reporting: TASS reported in 2021 that Russia would provide a $25 billion loan to Egypt, that the loan would cover 85 percent of the estimated $30 billion cost of the project, and that the interest rate on the loan was 3 percent, with repayment by Egypt to begin in October 2029.[122] Egyptian President Abdel Fattah al-Sisi stated in 2015, when the financing arrangement was reached, that the loan would be repaid over 35 years.[123] In 2017, Daily News Egypt reported that the repayment term of the loan was 22 years starting in 2029.[124]

Project status: The Nuclear Power Plants Authority in Egypt has submitted construction applications to the national regulator for El Dabaa units 1, 2, 3, and 4.[125]

Hungary

IGA details: A 2014 IGA between Hungary and Russia includes a loan offer of up to €10 billion for the provision of services and supply of equipment for the design, construction, and commissioning of power units 5 and 6 of the Paks nuclear power plant.[126] The loan was to be used by Hungary to finance 80 percent of the value of the contract approved for the performance of work and supply of equipment concluded between Russian and Hungarian organizations. The loan was to be used by Hungary between 2014 and 2025, and the used loan amounts were to be repaid over a period of 21 years, starting on the first March 15th or September 15th after the commissioning of units 5 and 6, but no later than March 15, 2026. The interest rate on the loan grew from 3.95 percent during the loan use years, to 4.5 percent during the first seven years of loan repayment, to 4.8 percent during the subsequent seven years of loan repayment, to 4.95 percent over the last seven years of loan repayment. A protocol was negotiated in 2021 to extend the loan use period and delay the start of repayment, among other changes.[127]

News reporting: World Nuclear News reported in 2014 that the Russian government had offered a loan of up to €10 billion out of the estimated €12.5 billion cost of the project, with repayment starting after commissioning (but not later than March 15, 2026) and a loan term of 21 years.[128] TASS reported in 2021 that Russia and Hungary had negotiated a protocol to the agreement that allowed for repayment of the used portion of the loan to begin five years later than originally agreed, though the repayment period was reduced from 21 years to 16 years.[129] Nuclear Engineering International reported in 2021 that the terms of the agreement had been renegotiated on account of significant delays in obtaining approval for the project from the European Commission.[130]

Project status: The construction license application to build Paks units 5 and 6 was submitted in June 2020 to the Hungarian Atomic Energy Authority (HAEA).[131] The HAEA was originally supposed to review the application within 12 months, but in September 2021 it stated that it needed more time before it could render a decision on a construction license.

India

IGA details: A 2008 Russia-India IGA stated that the Russian party would provide India a loan and/or a state guarantee to ensure financing of up to 85 percent of the cost of Russian supplies and services, including nuclear fuel and control rods, for the construction of an additional four power reactors at the Kudankulam site.[132] A 2012 Russia-India IGA provided a $3.4 billion loan to support construction of units 3 and 4 at the Kudankulam site with an interest rate of 4 percent, in addition to an $800 million loan for nuclear fuel and control rods.[133] The first loan was for use between 2012 and 2022 and the second between 2014 and 2024, with repayment terms of 14 and 4 years, respectively.

News reporting: A 2012 World Nuclear News article reported that Russia was to supply up to $3.5 billion in export finance to support units 3 and 4 at Kudankulam, which would be enough to finance 85 percent of the value of the works, supplies, and services provided by the Russian companies to build the VVER reactors, in addition to an $800 million loan for fuel supplies.[134] The same article noted the interest rate on the loan would be 4 percent per year and the two credit lines would be repayable over 14 and 4 years, respectively, from one year after the start of power generation.

In 2017, the India Times and Nuclear Engineering International reported that Russia was lending India $4.2 billion to support construction of Kudankulam units 5 and 6, which together were expected to cost $7.7 billion.[135]

Project status: Kudankulam units 1 and 2 (whose construction was also reportedly supported by Russian loans) started operations in 2013 and 2016, respectively. Units 3 and 4 began construction in 2017, and units 5 and 6 started construction in 2021.

Equity Investments

Turkey

IGA details: A 2010 Russia-Turkey IGA defines the "Project Company" that will implement the reactor project as a joint stock company to be formed soon after the agreement is signed.[136] The IGA states that the total number of Russian shares in the Project Company at any time must be at least 51 percent. It also states that the general contractor for the construction of the nuclear reactors will be the Russian company Atomstroyexport, and that Turkish citizens are to be trained free of charge—partly on a full-scale simulator to be supplied by Russia at the reactor site—and widely involved in the operation of the nuclear plant.

The Turkish side is obligated under the 2010 agreement to conclude a power purchase agreement with the Project Company. The agreement guarantees the purchase of 70 percent of units 1 and 2, and 30 percent of units 3 and 4, within 15 years of the commencement of commercial operation for each unit at a weighted average price of 12.35 US cents per kWh. The remaining percentages of the output are to be sold on the free energy market either independently or through a retain electricity supplier. After the expiration of the power purchase agreements, 20 percent of the net profits will go to the Turkish side.

News reporting: A 2017 World Nuclear News article reported that the Turkish grid operator Turkish Electricity Trading and Contracting Corporation had guaranteed investors in the project around $123 per MWh (i.e., 12.3 cents per kWh) for 70 percent of the output of the first two reactors and 30 percent of that of the second two, with the remainder to be sold on the open market. It also reported that Rosatom would pay 20 precent of the total profits back to the Turkish state after the first 15 years and would provide fuel for the lifetime of the plant.

In a 2021 interview with Nuclear Engineering International, a Rosatom official explained that in the "build-own-operate" model being implemented with the Akkuyu project, "The vendor provides the project financing, while the customer country creates all the preconditions necessary for project implementation. Once construction is complete, the facility's ownership remains with the vendor, who is responsible for its operation and receives profit from it."[137] The same official noted that the relevant power purchase agreement for the Akkuyu reactors had been signed and that it guaranteed the Russians a weighted average tariff for 70 percent of the electricity from units 1 and 2 and 30 percent of the electricity from units 3 and 4 for the first 15 years of each unit's operation. The Akkuyu project is the first to utilize the Russians' build-own-operate model, where Russia trains Turkish citizens to replace Russian personnel at the plant within 10 to 12 years.[138] The total cost of the four VVER-1200 reactors at the Akkuyu site has been estimated at $20 billion.[139]

Project status: The first three reactors at the Akkuyu site are already under construction, with the first unit estimated to begin operations in 2023, and a construction license was issued for the fourth unit in late 2021.[140]

Finland

IGA details: Russia and Finland signed an IGA in 2014 stipulating cooperation in the use of nuclear energy for peaceful purposes.[141] In 2014, the Russian government allocated €2.4 billion from its National Wealth Fund to support the construction of the Hanhikivi 1 VVER project in Finland.[142]

News reporting: A new company called Fennovoima Oy was created in 2007 to carry out the development of a new reactor project, and the Hanhikivi site was chosen in 2011. In April 2021, Fennovoima reported that Russia had granted a shareholder loan of €2.4 billion and that the total cost of the project had risen from €6.5–7 billion to €7–7.5 billion.[143] Rosatom officials have stated in interviews[144] that Russia has a 34 percent stake in the project—and Rosatom's website continues to state the same[145]—even as cost estimates for the project rise.

Project status: Fennovoima Oy applied for a construction license from the Finnish regulator in 2015 and may have obtained a construction license in 2022,[146] although the Russian invasion of Ukraine appears to have ended this project.[147]

APPENDIX 2: DETAILS OF CHINESE FINANCING FOR REACTOR EXPORTS

Exports to Pakistan

CHASNUPP 1 began construction in 1993 and was connected to the grid in 2000. Like the other three units built at the Chashma site, it is a 300 MW PWR supplied by the China National Nuclear Corporation.

CHASNUPP 2 began construction in 2005 and started operations in 2011.[148] To finance this project, CHEXIM pledged two different loans of varying debt size, interest rate, and tenor. The larger loan was around $RMB 1,600,000,000 (or approximately $200 million at the time).[149] CHEXIM also provided a loan of $150 million with a repayment term of 20 years and a 3 percent interest rate.[150]

CHASNUPP 3 and 4 were announced in 2009 at a total projected cost of $2.37 billion, with approximately $1.6 billion financed by CHEXIM through three 20-year low-interest loans. The largest of these loans was $1 billion offered at a 2 percent interest rate[151]; the second largest was a $474 million loan at a higher interest rate of 6 percent[152]; and a third loan of close to $108 million was provided at a 1 percent interest rate.[153] Construction of both units began in 2011, and they were connected to the grid in 2016 and 2017, respectively.

China's more recent exports to Pakistan are all the Hualong One design—a 1,100 MW PWR derived from French reactor technology. Two Hualong One reactors are operating in China at the Fuqing site, and another is operating in Pakistan at the Karachi site. A second Hualong One reactor at the Karachi site has been connected to the Pakistani electrical grid.[154]

For the two Hualong One reactors exported to the Karachi nuclear power plant (KANUPP 2 and 3), CHEXIM provided $6.5 billion in credit in 2014 out of the $9.59 billion total cost[155] in the form of three loans with 20-year repayment terms. The largest loan was $4 billion at a 2 percent interest rate[156]; a second loan was $2.250 billion at a 6 percent interest rate[157]; and a third loan was approximately $429 million at a 1 percent interest rate.[158]

In 2017, the planned construction of a Hualong One unit at the Chashma site was announced. This unit would be the fifth at the site, though at the end of 2021, construction had not yet begun.[159]

Chinese Financing of Nuclear Energy Projects Outside of Pakistan

Although thus far China has only exported reactors to Pakistan, there are signs that it plans to export its reactors to additional countries in the coming decades. Rather than offer loans solely to support its own reactor exports—as Russia has been doing—China has also made offers to support non-Chinese-origin reactor projects as a means of gaining entry to certain markets.

In the United Kingdom, CGN is supplying a 33.5 percent stake in the Hinkley Point C expansion (to build French EPR reactors). This was initially part of a strategy by China of building its reactors in the United Kingdom—specifically, a Hualong One nuclear power plant at the

Bradwell site—and China recently obtained UK nuclear safety regulatory approval for the Hualong One design. While the project at Hinkley Point appears likely to continue with a Chinese minority stake, the future of Chinese involvement at the Bradwell site and any other UK site appears unlikely due to rising concerns over security interests.[160]

In early 2022, it was announced that China will export its Hualong One reactor to the Atucha site in Argentina. Chinese banks, led by the Industrial and Commercial Bank of China, will help with financing, including a loan of about $8 billion that would cover 85 percent of the project cost.[161] Nucleoeléctrica Argentina—which operates the two existing power reactors at the Atucha site—and China National Nuclear Corporation have signed an engineering, procurement, and construction contract for what would be the third power reactor at the Atucha site.[162] Reporting previous to the 2022 announcement described a loan from the Industrial and Commercial Bank of China loan in the amount of $6.715 billion with a 4.5 percent interest rate and a 20-year repayment term.[163]

APPENDIX 3: HISTORICAL DETAILS OF EXIM BANK INVOLVEMENT IN US REACTOR EXPORTS

EXIM's involvement with financing nuclear projects appears to have begun in the early 1950s with assistance to foreign uranium supply plants—not reactors—to produce uranium for US consumption.[164] However, after President Eisenhower delivered his "Atoms for Peace" speech in December 1953, the US government moved to support nuclear energy cooperation with other countries.

In 1956, EXIM and the US Atomic Energy Commission issued a joint statement that they had agreed to assist with the construction of atomic power plants in countries that entered into agreements stipulating cooperation with the United States on civil nuclear energy. In particular, the bank said that it was prepared to "consider loans to privately owned public utility companies as well as to governments on appropriate terms to finance the construction of atomic power plants abroad."[165]

Along these lines, EXIM made its first atomic energy–related loan in October 1956 to Spain for $385,000 with a 5 percent interest rate and a repayment period of two years after the signing of the contract. The loan assisted Spain in purchasing a research reactor and related equipment from a US supplier.[166] In 1958, the bank authorized another $350,000 loan to support a research reactor sale to Israel with an interest rate of 5 percent and a repayment period of two years.

Not long after these smaller research reactor loans, the bank announced actions to support larger power reactors. EXIM reported a loan in 1959 to the newly created European Atomic Energy Community (Euratom), which consisted of only six members at the time: France, Germany, Italy, Belgium, Luxembourg, and the Netherlands. EXIM annual reports and press releases from this period only describe the terms of the overall loan to Euratom: $135 million (out of a proposed $350 million overall program, with the remainder to be raised from European sources), repayable over 20 years with an interest rate of 4.5 percent.[167] The low interest rate was acknowledged by the bank to be "below the bank's normal rate for development loans" but was established to facilitate the advancement of the peaceful use of atomic energy. The goal for this loan was described in bank documents as an installed generating capacity of 1000 megawatts in Euratom countries and US reactors deployed in six to eight nuclear power plants. The EXIM credit was limited to no more than 40 percent of the total cost of any plant, and the reactors were to be completed and placed in operation between December 31, 1963, and December 31, 1965.

The EXIM annual reports and press releases from the 1950s and 1960s do not list which individual reactor projects the Euratom loan was used for.[168] However, Westinghouse-designed PWRs and GE-designed BWRs with at least some US involvement, if not financial support, were subsequently constructed in France, Germany, Italy, the Netherlands, and Belgium in the 1960s.[169]

Also in 1959, EXIM issued its first credit for a single atomic power project: the Enrico Fermi installation in Italy.[170] The credit of $34 million (out of an estimated $64 million for the project) was repayable over 15.5 years starting in 1964, and Westinghouse was to provide the equipment and design for the 165 MW PWR.

In the 1960s and 1970s, EXIM went on to authorize loans supporting US PWR and BWR exports to Spain, Japan, Taiwan, the ROK, Brazil, Mexico, Yugoslavia (in what is now Slovenia), and the Philippines.

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11. The IAEA's power reactor database is hosted at: https://pris.iaea.org/pris/.

12. The list of "exported" reactors connected to electrical grids between 2000 and 2021 from the IAEA PRIS set is: Angra-2, Temelin-1, Chasnupp-1, Ling AO-1, Ling AO-2, Qinshan 3-1, Temelin-2, Qinshan 3-2, Khmelnitski-2, Rovno-4, Tianwan-1, Tianwan-2, Cernavoda-2, CEFR, Bushehr-1, Chasnupp-2, Kudankulam-1, Atucha-2, Kudankulam-2, Chasnupp-3, Tianwan-3, Chasnupp-4, Haiyang-1, Haiyang-2, Sanmen-1, Sanmen-2, Taishan-1, Tianwan-4, Taishan-2, Belarusian-1, Barakah-1, Kanupp-2, and Barakah-2.

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14. World Nuclear News, "Siemens Quits the Nuclear Game," September 19, 2011, https://world-nuclear-news.org/Articles/Siemens-quits-the-nuclear-game.

15. At the beginning of 2022, the IAEA did not list any CANDU as "under construction" or "planned," though there has been discussion in Romania around completing two CANDUs at the Cernadova site. The construction of these projects was halted in 1991. See World Nuclear News, "First Contract Signed for Cernavoda Completion," November 26, 2021, https://www.world-nuclear-news.org/Articles/First-contract-signed-for-Cernavoda-completion.

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17. The archived EXIM annual reports and press releases do not appear to detail financing terms for all nuclear projects that EXIM supported historically. For example, Congressional documents found in the Library of Congress indicate EXIM financial support for nuclear exports to Sweden, of which no mention is made in the EXIM annual reports and press releases.

18. The IAEA PRIS system lists Ukraine as having two VVERs under construction, with the first unit beginning construction in 1986. However, the project appears to have stalled out in the 1990s and more recently Ukrainian entities have begun discussions of other possibilities. See World Nuclear News, "Completion of Khmelnitsky 3 'Begins' in Ukraine," November 9, 2021, https://www.world-nuclear-news.org/Articles/Completion-of-Khmelnitsky-3-begins-in-Ukraine.

19. Rosatom, "Projects," accessed February 16, 2022, https://rosatom.ru/en/investors/projects/.

20. This report was largely researched and written before the invasion, and it does not try to predict or analyze the full implications of the invasion for Russian nuclear commerce. The loan and equity details described are still indicative of Russia's approach to supporting its reactor exports in future years.

21. For example, Finnish officials have indicated that they will not move forward with the Hanhikivi project as a result of Russian aggression in Ukraine. See World Nuclear News, "Fennovoima Cancels Hanhikivi 1 Contract with Russia," May 3, 2022, https://www.world-nuclear-news.org/Articles/Fennovoima-cancels-Hanhikivi-1-contract-with-Russi. Separately, the Russian reactor project at El Dabaa in Egypt could be threatened by international sanctions. See Jung Suk-yee, "Sanctions against Russia Likely to Affect Korea's Nuclear Power Project in Egypt," Business Korea, March 3, 2022, http://www.businesskorea.co.kr/news/articleView.html?idxno=88454.

22. CNTD, a website dedicated to collecting Russian legal documents, explains that it is an electronic fund of "legal and regulatory technical documents." Accessed April 15, 2022, https://cntd.ru.

23. The authors found no evidence that Russia had provided a loan to the Czech Republic for Temelin-1 and -2, and one *Nuclear Engineering International* article from 1998 claimed that the Czech entity building nuclear plants financed its capital programs from its own

resources and loans. See Nuclear Engineering International, "Czech Republic," November 30, 1998, https://www.neimagazine.com/features/featureczech-republic-721/. A 2001 Russia-Ukraine agreement discusses the negotiation of a separate agreement for a loan to support Khmelnitski-2 and Rovno-4, but the authors could not find the separate agreement, nor any news reports with the financing details.

24. A 2021 article from the Iranian press mentions a Russian loan to Iran to develop the Bushehr power plant (Islamic Republic News Agency, "Russia's Allots $5b Loan to Iran to Develop Bushehr, Ramin Power Plants," September 12, 2021, https://en.irna.ir/news/84467902/Russia-s-allots-5b-loan-to-Iran-to-develop-Bushehr-Ramin-power) but does not describe any of the terms. A 1995 Russia-Slovakia agreement mentions state loans of up to $80 million, with interest rates tied to LIBOR rates, and a repayment period of three years, though given the timing it seems more likely to have been applied to Mochovce units 1 and 2 (Official Internet Portal of Legal Information [the Russian government's official website], accessed August 8, 2022, http://pravo.gov.ru/proxy/ips/?doc_itself=&backlink=1&nd=102035962&page=1&rdk=0#I0). The IAEA lists Khmelnitski units 3 and 4 as VVERs that are "under construction" and whose construction began in 1986 and 1987, though recent reporting indicates that Ukraine will not pursue those projects, at least as VVERs. See World Nuclear News, "Completion of Khmelnitsky 3 'Begins' in Ukraine," November 9, 2021, https://www.world-nuclear-news.org/Articles/Completion-of-Khmelnitsky-3-begins-in-Ukraine.

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164. From EXIM Bank, *1959 Twenty-Fifth Anniversary Review*, 1934–1959, 105, https://www.digitalarchives.exim.gov/digital/collection/ExImD01/id/7962/rec/3. In early 1951, the AEC discussed with EXIM the possibility of offering financing to support a program to produce uranium oxide in the Union of South Africa. EXIM originally authorized "$35 million for the establishment of individual credits to mining companies in the Union of South Africa to assist in financing two thirds of the cost of constructing plants for the production of uranium from the residue of gold-bearing ore from which the gold has been extracted. The remaining one third of the cost of each plant was financed by the British Ministry of Supply. Credits to six mining companies were established early in 1952. This initial commitment of $35 million was subsequently increased from time to time to a total of $126 million." EXIM also assisted in "financing the production of uranium oxide for sale to the Atomic Energy Commission through a 1952 loan of $5.9 million to the Government of the State of South Australia to finance two thirds of the cost of development and equipment of a mine and the construction of ore processing facilities, the remaining one third being financed by the British Ministry of Supply."

165. EXIM Bank, "EXIM Bank Press Release," press release, October 16, 1956, https://www.digitalarchives.exim.gov/digital/collection/ExImPR01/id/1092/rec/1.

166. EXIM Bank, *July–December Semiannual Report 1956*, 6, https://www.digitalarchives.exim.gov/digital/collection/ExImD01/id/5619/rec/1.

167. EXIM Bank, "EXIM Bank Press Release," press release, August 17, 1959, https://www.digitalarchives.exim.gov/digital/api/collection/ExImPR01/id/1692/page/0/inline/ExImPR01_1692_0.

168. With one exception: The 1962 EXIM Bank annual report does break out $16.5 million to the Société d'Énergie Nucléaire Franco-Belge de Ardennes for "equipment and services for an atomic electric power plant to be located in France bordering Belgium." This would appear to be consistent with the Chooz-A power plant, located in France, near the border with Belgium.

169. E.g., the IAEA PRIS database lists Germany as connecting a BWR to its grid in 1960 with GE listed as a nuclear steam supply system (NSSS) supplier; Belgium connected a PWR to its grid in 1962 with Westinghouse listed as a NSSS supplier; Italy connected both a PWR and a BWR to its electrical grid in 1964, where Westinghouse and GE are listed as

NSSS suppliers for each, respectively; France connected a PWR to its grid in 1967 with Westinghouse listed as a NSSS supplier; and the Netherlands connected a BWR to its grid in 1968 where GE is not listed as a NNSS supplier, but the model is described as a "GE design." The sixth country, Luxembourg, has never hosted a nuclear power plant. A 1984 EXIM annual report states that the bank financed its first sales of nuclear reactors, fuel, and equipment to Israel, France, Germany, and Italy in fiscal year 1959, which would support the notion that the 1959 Euratom loan assisted reactors in at least France and Germany.

170. EXIM Bank, "EXIM Bank Press Release," press release, November 1, 1959, https://www.digitalarchives.exim.gov/digital/api/collection/ExImPR01/id/1731/page/0/inline/ExImPR01_1731_0.

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