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STRENGTHENING NUCLEAR ENERGY COOPERATION BETWEEN THE UNITED STATES AND ITS ALLIES

BY MATT BOWEN
JULY 2020

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Columbia University CGEP
1255 Amsterdam Ave.
New York, NY 10027
energypolicy.columbia.edu

@ColumbiaUenergy

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ABOUT THE AUTHOR

Dr. Matt Bowen is a research scholar at the Center on Global Energy Policy (CGEP), focused on nuclear energy, waste, and nonproliferation. Before joining CGEP, he held positions at Clean Air Task Force and the Nuclear Innovation Alliance. Bowen spent over four years at the US Department of Energy (DOE) as a senior advisor in the Office of Nonproliferation and Arms Control from 2011 to 2015. He left DOE in January 2017 as an associate deputy assistant secretary in the Office of Nuclear Energy. Bowen has a PhD in theoretical particle physics from the University of Washington, Seattle and a BS in physics from Brown University.

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EXECUTIVE SUMMARY

Nuclear energy cooperation between the United States and its allies has been important for over a half century. Bilateral cooperation agreements with key countries date back to the 1950s, and the United States played a principal role in the development of several allied nuclear energy programs. Today, the international nuclear energy marketplace has changed, and the supply chain is globalized—the US program, for example, depends on working with allies for major safety-related components. However, limitations imposed by legacy US statutes and other obstacles are hampering greater collaboration in areas that would enhance the country's nuclear program today. Developing advanced reactors to produce dispatchable zero-carbon electricity and heat as part of global efforts to address climate change would be aided by greater cooperation and utilization of resources and financing across countries.

Deeper cooperation with like-minded allies would also allow the United States to better compete against other supplier countries that have different commercial and geopolitical objectives. If the challenges facing the US nuclear program are not overcome, the country risks further ceding its role as a leading nuclear technology exporter to China and Russia. Already China and Russia are growing their domestic nuclear energy programs and offering attractive financing to prospective customers of this technology around the world. These nuclear competitors may place differing priorities on areas such as nonproliferation, and therefore maintaining a US role in the nuclear supplier regime is connected with national security considerations.

This paper, part of the Center on Global Energy Policy at Columbia University's nuclear power program, examines part of what may be required for the United States to regain momentum in the nuclear power industry after an erosion of domestic capabilities stemming from a long hiatus in new reactor orders. The paper discusses the historical importance of nuclear cooperation between the United States and allies, some of the challenges that the US and some allied nuclear energy programs are facing, and how cooperation could be reinvigorated to the benefit of the United States and its allies.

In short, the paper finds:

- Advanced reactor development and demonstration are both expensive endeavors: each can cost over a billion dollars. Greater cooperation between the United States and allies such as Canada, France, Japan, the Republic of Korea, and the United Kingdom would enable more sources of investment and help keep development costs low by utilizing existing facilities and capabilities.
- Laws dating back to 1954, however, have created barriers to foreign investment in domestic nuclear reactors—even among the country's closest allies. These laws inhibit efforts for nuclear energy cooperation in areas that are becoming critical in the modern economy, particularly investment in new US reactor projects and preserving existing reactors. The international nuclear energy marketplace has changed

dramatically since these provisions were created, making these legacy restrictions increasingly problematic.

- In 1999, the US Nuclear Regulatory Commission (NRC) proposed amending parts of the Atomic Energy Act of 1954 to enable the NRC to more effectively manage modern corporate structures and a globalized supply chain. This proposal, not since enacted, would help to facilitate greater cooperation on advanced reactor demonstration between the United States and its allies.
- Also, current international programs in the US Department of Energy's Office of Nuclear Energy are not structured to facilitate greater cooperation between the United States and its allies on advanced reactor demonstration. Either reorienting existing programs or establishing new ones with this aim would increase the likelihood of successful demonstration of advanced reactors.

INTRODUCTION

The United States has several reasons to remain engaged on nuclear energy development, chief among them addressing climate change.[1] The nation has cooperated with key allies on nuclear energy for decades, but given the challenges associated with advanced reactor development and demonstration explained in this paper as well as the urgency for zero-carbon power as the world aims to meet climate goals, the author argues that more cooperation would advance US interests and accelerate the availability of new nuclear energy options.

In this report, a US "ally" is defined to be any country with which the United States has a mutual defense agreement, whereby each nation is committed to assist in each other's defense in the face of an attack.[2] These allies include countries with which the United States has a long history of nuclear energy cooperation, such as Canada, France, Japan, the Republic of Korea (ROK), and the United Kingdom (UK).

There are several reasons to focus on nuclear energy cooperation between the United States and its allies. Historically, geopolitical relationships have always mattered with respect to US nuclear energy cooperation. Following the passage of the Atomic Energy Act of 1954, which made greater cooperation with other nations possible, the United States was immediately more inclined to pursue nuclear energy activities with the free world, and less inclined to work with Communist-controlled countries, such as China and the Soviet Union.[3]

A mutual defense agreement is a strong statement about the relationship between two countries. US regulations addressing nuclear energy cooperation with other countries at times have divided the world into multiple groups ranging from more desirable to less desirable.[4] Not surprisingly, US allies tend to fall into the former category, and the US government has previously considered the presence of mutual defense agreements as part of its deliberations on nuclear energy cooperation.[5] Notably, the relatively small group of countries which have large nuclear energy programs, substantial financial resources, and a willingness to invest in advanced reactor demonstration also have mutual defense agreements in place with the United States (as well as intelligence-sharing and other agreements, as chapter 2 discusses). Part of the rationale for deeper cooperation with like-minded US allies is to better compete against other supplier countries such as Russia and China, who have different commercial and geopolitical objectives and thus may place differing priorities on areas such as nonproliferation.[6]

This is not to suggest that the United States should cooperate only with countries that have mutual defense agreements with it; rather, US allies represent a logical starting point for efforts to deepen nuclear energy cooperation in ways discussed in this paper.

Historical Cooperation with US Allies

In the early years of Atoms for Peace, the United States invested in and explored multiple reactor types as part of the Power Reactor Demonstration Program.[7] Eventually, the United States pursued mainly two types of reactors, both using light water as a coolant: boiling water reactors (BWRs) and pressurized water reactors (PWRs). All of the operating reactors in the

United States today are either BWRs or PWRs, and light water reactors are now the most common type of power reactor around the world.

The United States went on to assist many other countries with their nuclear energy programs, including allies such as the ROK, Japan, and France, all of which signed nuclear cooperation agreements with the United States in the mid-1950s and have maintained strong ties ever since. Each of those countries, for example, ultimately based the majority of their nuclear energy programs on US BWR or PWR technology. A 1977 analysis by RAND observed that in 1976, more than three-fourths of the commercial-scale power reactors in the world were light water reactors. The study further noted, "Few were of other than American design; most were types conceived, developed, and successfully demonstrated by the US government and private American firms between 1950 and 1976."[8] In other words, US investments in demonstrating light water reactor technology in the early Atoms for Peace years led to a predominant role for America in the international nuclear energy market.

Two US allies, Canada and the UK, took a somewhat different path and built their nuclear energy programs based on non–light water reactor designs. The British still operate a fleet of 14 gas-cooled reactors that are not of American origin, although all of these reactors are expected to retire in the next decade. The UK's most recent reactor to enter operation was a light water reactor, and the new builds the country is actively considering are essentially all light water reactors.[9] Canada currently operates a fleet of 19 heavy water reactors that are also not of American origin. Similarly, however, the country is considering new reactor builds that would appear to shift away from its domestic heavy water designs and toward either light water–based reactors or other concepts.[10]

The US nuclear industry has undergone substantial change since the early decades of Atoms for Peace, including an erosion of domestic capabilities as a result of a long hiatus in new reactor orders. For example, the United States originally manufactured the major safety components for its domestic and exported reactors. Today, the supply chain has become globalized, and the United States no longer has the capability to forge, for instance, large pressure reactor vessels for even the large light water reactors designed by Westinghouse. The ROK is the manufacturer for the steam generators and pressure vessels used in the Westinghouse AP1000 construction project at the Vogtle site in Georgia. Similarly, another development is the substantial presence of US allies in the US nuclear power program. The French-owned company, Framatome, for example, has a fuel fabrication facility in the state of Washington that makes nuclear fuel for about one in four US reactors, or 5 percent of total US electricity generation.[11] Cross-investment and foreign corporate parentage are now common in the US nuclear energy industry, as even Westinghouse was for several years owned by the Japanese conglomerate Toshiba and is now owned by Brookfield Business Partners, a subsidiary of Canada's Brookfield Asset Management Inc.[12] GE-Hitachi Nuclear Energy is a global alliance that was established between the US company General Electric and the Japanese company Hitachi.

Further signs of erosion in the US nuclear energy base can be found in the enrichment sector. While the United States used to lead the world in enrichment capability, its last US-owned gaseous diffusion enrichment facility in Paducah, Kentucky, ceased operations in 2013. Today, the URENCO LES gas centrifuge enrichment facility in New Mexico is the only operating commercial enrichment plant in the United States, and it is capable of meeting nearly a third of US nuclear power plant demands. URENCO is owned by UK, Dutch, and German entities and operates uranium enrichment facilities in each of those countries. All of these facilities export enriched uranium to the United States to supply US nuclear power plants.

New Imperatives: Climate Change and Rising Competition from Russia and China

Nuclear energy cooperation with US allies has been important for over a half century and continues to this day. However, nuclear energy is witnessing challenges in some of these nations. Japan is still recovering from the 2011 tsunami that devastated the country and led to the nuclear accident at the Fukushima Daiichi nuclear power plant. The Moon administration in the ROK has announced that it will cancel planned new reactor builds and shut down existing reactors at the end of their operating licenses. In the United States, cheap natural gas in particular is threatening the operation of existing nuclear power plants and challenging new reactor builds. The loss of existing dispatchable zero-carbon power plants and the foreclosure of new build zero-carbon power options can only make climate targets less attainable.[13]

Separately, China and Russia are growing their nuclear energy programs and offering attractive financing to prospective customer nations. Russia is leading the export market for reactors, and China is pursuing the largest domestic reactor build in the world and thereby positioning itself for future ascendancy.[14] As has been observed elsewhere, the United States and its allies have traditionally been the great champions of nonproliferation, and there are attendant national security concerns regarding Russian and Chinese dominance of the international nuclear energy marketplace.[15] Cooperation on nuclear energy between the United States and its allies—whether it is combined investment in advanced reactor development, shared use of existing facilities (e.g., for research and testing), exchanges of nuclear material and equipment, or construction and operation of new reactors—appears more necessary than ever to secure and advance US interests.

As the rest of this report argues, given the new imperatives of climate change and rising competition from Russia and China, the United States can and should pursue deepened cooperation with its allies to help demonstrate innovative new reactor concepts that improve nuclear safety and competitiveness. While there are likely many ways in which the United States could enhance cooperation with its allies, this report focuses on a few tangible examples for deepening or facilitating additional partnerships on reactor development, demonstration, and operation.

Chapter 2 looks at one legacy statute from 1954 that inhibits greater cooperation today between the United States and its allies, and argues for Congress to modernize the anachronistic provision. The law in question has caused problems for reactor projects involving even comparatively small amounts of investment from US allies (e.g., Japan) and has led to outright rejection of reactor projects with majority investment from others (e.g., France). To avoid potential problems with future advanced reactor projects (e.g., involving

Canadian or British entities), the chapter argues that Congress should fix the statute along the lines of what the US Nuclear Regulatory Commission (NRC) first proposed back in 1999.

Chapter 3 examines the challenge of financing both the development and demonstration of new advanced reactor concepts, as well as the potential benefits from cooperation with entities from US allies. The case study discussed in chapter 3 involves NuScale Power, a US company, and its partnerships with entities from three US allies: France, the United Kingdom, and the ROK. Those mutually beneficial partnerships have helped NuScale to assemble the investment needed to develop its advanced reactor concept, as well as to reduce the total development costs it would otherwise need. Other US advanced reactor companies may want—or even need—to find partnerships with entities from US allies for similar reasons.

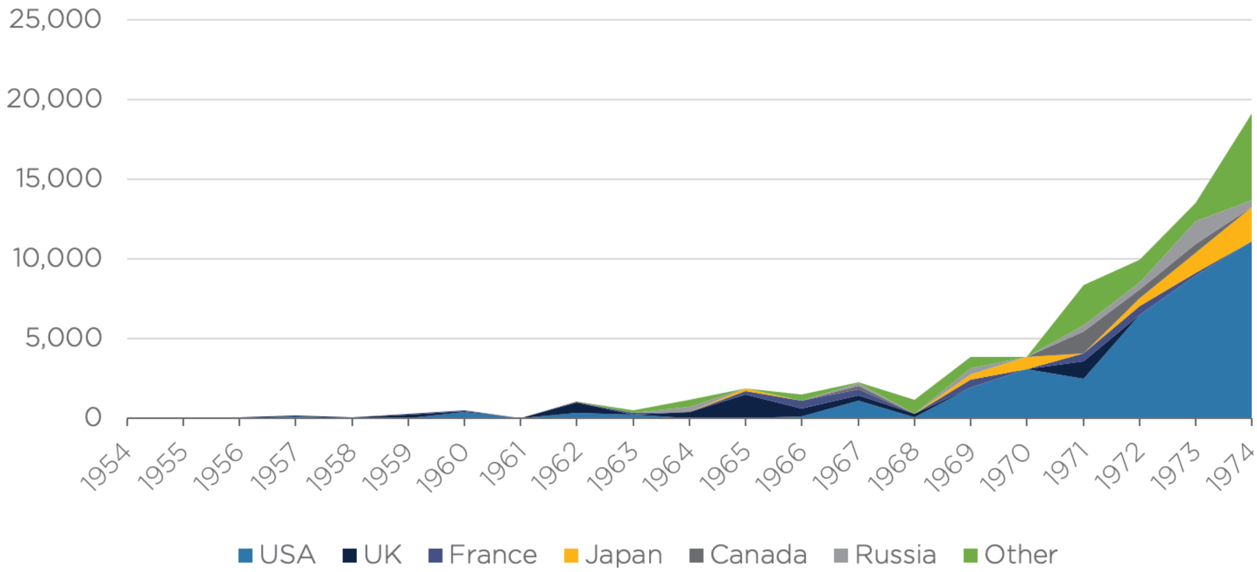
Along these lines, chapter 4 looks at the international nuclear energy programs sponsored by the US Department of Energy (DOE) and the role they could potentially play in facilitating discussions between the US government, US advanced reactor companies, and allied governments and private entities from those allied countries. A reorientation of DOE's international nuclear energy programs toward advanced reactor demonstration would make sense for a number of reasons. Those reasons include, among others, the 2015 Paris Agreement,[16] the related announcements of Mission Innovation and the Breakthrough Energy Coalition initiatives, recently enacted state clean energy laws, recently introduced congressional legislation on advanced reactor demonstration, and export policy developments involving China and Russia.

Finally, chapter 5 reviews observations from the other chapters and draws conclusions.

A LEGACY BARRIER TO GREATER COOPERATION: THE 1954 FOCD STATUTE

The regulations over US nuclear energy activities largely come from the Atomic Energy Act of 1954 (AEA), as amended. However, when Congress passed the AEA, it was establishing the legal framework for a nascent industry—not a single commercial power reactor was in operation around the world at the time. As figure 1 shows, reactor capacity additions to national electricity grids were fairly small until the 1970s.

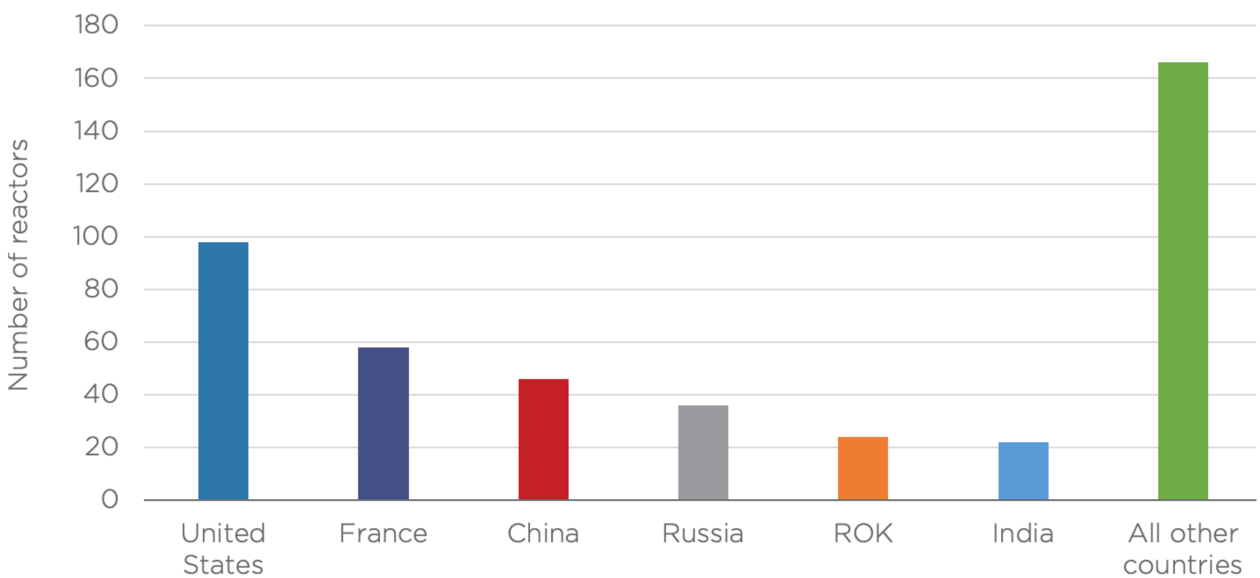
Figure 1: Gross nuclear energy capacity (MWe) added by grid connection year and host nation, 1954–1974



Notes: IAEA Power Reactor Information Service

By contrast, in 2018, there were 450 nuclear reactors operating in 30 countries with 396,000 MWe of total capacity, as shown in figure 2.

Figure 2: Number of power reactors in operation in 2018

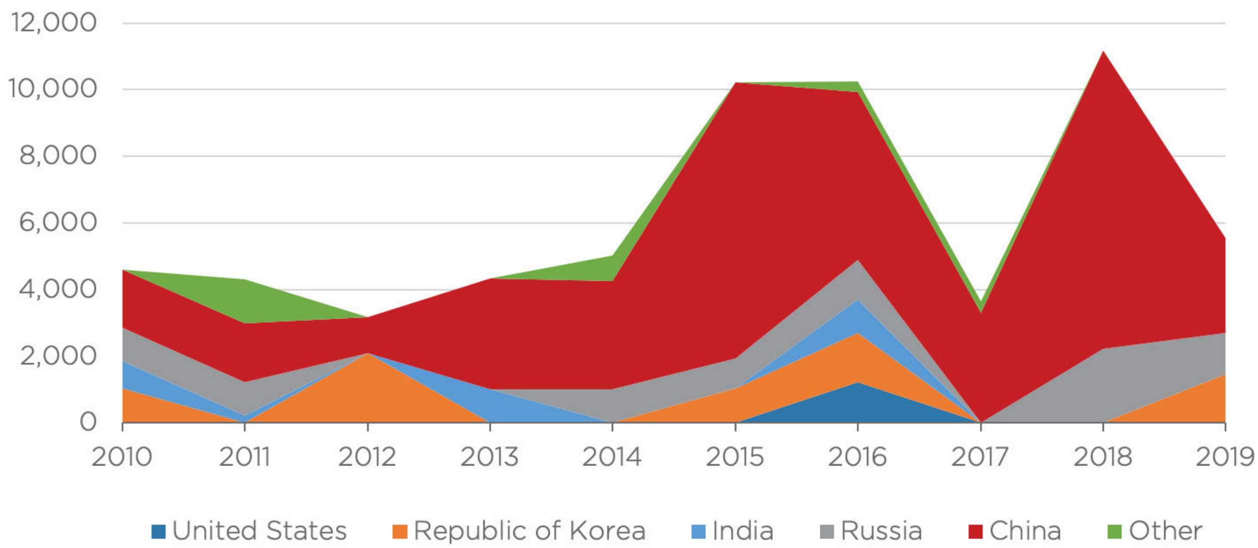


Note: The IAEA lists Japan as having 38 reactors in operation, though at the end of 2019, only nine have restarted following the Fukushima accident.
Source: International Atomic Energy Agency, "Nuclear Power Status 2018," https://pris.iaea.org/PRIS/19-01767E_POS_PRIS_NPS_map_2018_FINAL2.pdf.

Many other changes have taken place since the AEA was passed nearly 70 years ago. When the US nuclear program began, the United States manufactured all of the major components for its reactors (e.g., pressure vessels). Today, the international supply chain for reactors is globalized, and both existing and under-construction reactors in the United States rely on equipment and materials from Canada, the UK, France, Japan, the ROK, and other suppliers. This is also in part necessary, as after decades of not building new reactors, the US supply chain has atrophied. For example, as noted earlier, the ROK is supplying both the pressure vessels and the steam generators for the AP1000 reactors currently under construction in Georgia.

As figure 3 shows, nuclear energy markets have also changed greatly since the first two decades following the AEA's passage. New power reactor grid connections in the last decade largely have been in different countries (especially China) than those in figure 1 and in particular not in the United States. Corporate structures have also changed, as many US-based companies are now owned by parent companies in other countries (e.g., Westinghouse is owned by a Canadian company, Brookfield Business Partners, which acquired Westinghouse from the Japanese company Toshiba). In contrast to the US way of doing business, some of the leading reactor vendors, such as Rosatom, are state owned.

Figure 3: Gross nuclear energy capacity (MWe) added by grid connection year and host nation, 2010–2019



Note: Power uprates at existing reactors during this time period are not shown.
Source: IAEA Power Reactor Information Service

This chapter looks at one barrier to increased cooperation between the United States and its allies stemming from one sentence substantially in place since the AEA was passed in 1954. As the next subchapter discusses, Congress did not explain its intent behind this statutory provision, and its vagueness and inflexibility has created problems for many decades.

Origins and Regulatory Implementation

Section 103d of the AEA, as amended, contains the following passage:

> No license may be issued to an alien or any[17] corporation or other entity if the Commission knows or has reason to believe it is owned, controlled, or dominated by an alien, a foreign corporation, or a foreign government. In any event, no license may be issued to any person within the United States if, in the opinion of the Commission, the issuance of a license to such person would be inimical to the common defense and security or to the health and safety of the public.

The first sentence, referring to foreign ownership, control, and domination (FOCD), has been substantially in place since 1954. However, while the Joint Committee on Atomic Energy[18] (JCAE) hearings leading up to passage of the AEA had discussed the implications of allowing the private sector to develop nuclear power and the need to maintain national defense and security, according to the NRC, "there was no discussion concerning FOCD of reactor licensees or applicants."[19]

In addition, the FOCD sentence that passed into law was different than related language that had appeared in previous drafts of the AEA (e.g., discussing a limit on stock ownership by foreign entities[20]), and the Joint Committee on Atomic Energy did not explain why this draft language was changed in the final version. For example, Congress did not define “controlled” or “dominated” or explain how the two terms are different from one another. “Owned” was also not explained in terms of modern corporate structure, where a US company may be wholly or partly owned by a parent corporation (i.e., Congress did not illuminate its thoughts on direct versus indirect ownership). Thus, the NRC and the nuclear industry have been required to interpret a vague sentence with little guidance from its authors. Moreover, individuals within the NRC have interpreted its meaning in different and sometimes contradictory ways.

The FOCD restriction has been called “the primary legal barrier” to investment in the US nuclear reactor industry from outside the United States.[21] The NRC licenses new commercial power reactors under Section 103[22] of the AEA, and thus the FOCD provision applies to all of these projects. One implication of the FOCD provision is that no foreign entity (e.g., the French utility Electricite de France) can directly apply for and be given an NRC license to operate a power reactor in the United States. The NRC also has historically interpreted this provision to mean that a foreign entity cannot have 100 percent indirect ownership of an NRC license to operate a power reactor—that is, a US company that holds a power reactor license cannot be wholly owned by a UK company, for example. As noted later in this chapter, there does not appear to be a comparable statute for other energy technologies,[23] and foreign investment in US clean energy facilities has been an important part of their success.[24] Other energy companies in the United States may be wholly owned by foreign entities—for example, the Shell Oil Company in the United States is a US subsidiary of Royal Dutch Shell (a British-Dutch oil and gas company).[25] The FOCD restrictions do not extend to all nuclear facilities in the United States, however. For example, Westinghouse (owned by the Canadian company Brookfield Business Partners) operates a nuclear fuel fabrication facility in South Carolina, and URENCO (owned by the British, Dutch, and German governments) operates an enrichment facility in New Mexico.

In practice, the NRC staff conduct reviews of applications for power reactor licenses, license transfers, and license renewals to verify that they do not violate the FOCD restriction. 10 CFR Part 50.38, “Ineligibility of certain applicants,” states: “Any person who is a citizen, national, or agent of a foreign country, or any corporation, or other entity which the Commission knows or has reason to believe is owned, controlled, or dominated by an alien, a foreign corporation, or a foreign government, shall be ineligible to apply for and obtain a license.”

According to a 2014 NRC policy paper, the Standard Review Plan (SRP) that the NRC has followed in reviewing power reactor license applications for FOCD issues indicates that “ownership is not the sole determinant of FOCD and identifies a number of other factors, such as corporate governance structures, citizenship of key employees, and contractual and financial arrangements that must be considered to determine whether the foreign interest controls or dominates the license . . . in practice the NRC staff has not approved an application with more than 50 percent foreign ownership.”[26]

In the past, where an application has proposed indirect foreign ownership of a power reactor application—e.g., a Japanese company has some level of investment in the reactor—the applicants have submitted "Negation Action Plans" (NAPs) to "negate" foreign control and domination. These NAPs are intended to preclude foreign "control" and "domination" by requiring various mitigation measures, such as ensuring that key personnel (e.g., the chief executive officer or the chief nuclear officer) are US citizens. Prior NAPs have also created committees that are either majority or entirely composed of US citizens and have control or oversight over safety and security matters. The creation and implementation of these committees (e.g., paying committee member salaries) add costs to the associated nuclear energy projects.

The NAP measures add bureaucratic uncertainty and delay to commercial power reactor endeavors involving US allies. There is some uncertainty with regard to the exact measures the NRC will ultimately accept in approving a given NAP. Other power plants in the United States (e.g., solar, wind, natural gas, coal) are not subject to a similar FOCD restriction. Consequently, the AEA FOCD provision effectively reduces the value of nuclear power plants in comparison to these energy sources, placing a competitive burden on US nuclear power plants.

Most importantly, the NRC does not differentiate between countries in applying the FOCD restriction: applications involving investment from entities in the UK, Canada, and France are evaluated in the same way as applications that involve investment from entities in China, Russia, and North Korea. This contradicts US government policy elsewhere insofar as other nuclear energy–related laws and regulations (e.g., the NRC's 10 CFR Part 110 regulations or DOE's 10 CFR Part 810 regulations) explicitly factor in the geopolitical relationship between the United States and US allies. However, while the United States has signed mutual defense agreements with its allies pledging to potentially place its soldiers' lives at risk for one another's sake, this matters not in the reactor licensing context with regard to the FOCD restriction. Investments in nuclear energy projects by those same allies are treated no differently under FOCD evaluations than investments by more problematic (or completely unacceptable) sources.

Instances Where the Law Has Been Problematic

As might be expected, the FOCD provision's vague and ambiguous language has posed NRC implementation challenges. In a 2014 policy paper, SECY-14-0089, the NRC discussed 17 specific cases dating back to 1966 where the FOCD provision has been implicated before the NRC.[27] The countries involved in these cases were Canada, Cayman Islands, France, Germany, Guernsey, Japan, the Netherlands, Panama, Spain, Sweden, Switzerland, and the UK. Almost all of these countries have mutual defense agreements with the United States—and all have friendly relationships with the United States—leading to the observation that the FOCD provision has really only been problematic for projects involving nations that are, for the most part, US allies. At least in its review, the NRC did not list any instances of where the FOCD provision has blocked investment from a problematic nation.

Many published papers have discussed these different FOCD cases, which involved, for example, efforts by British companies to invest in US nuclear energy projects.[28] This section discusses three seminal cases to illustrate the problems posed by the FOCD provisions and the need for congressional intervention to resolve those problems. The first case occurred in 1983 and involved corporate parentage of a research reactor by a Swiss company. In that case, Congress made changes to US law to enable NRC authorization of the transaction following a determination that the project and the Swiss parentage did not present a safety or security risk to the United States. The other two cases, which were from more recent years and involved French and Japanese companies, illustrate how the FOCD provision has stymied commercial cooperation with US allies on nuclear projects. Those cases led to the NRC's "Fresh Assessment" of FOCD in 2014, which also is discussed and critiqued below.

Cintichem, Inc.

In 1983, the NRC received an application for the transfer of a research reactor in Tuxedo, New York, to Cintichem, Inc. Cintichem was a wholly owned Delaware subsidiary of Medi-Physics, Inc., a Delaware corporation. Due to upstream corporate ownership of Medi-Physics by a Swiss entity, the NRC found the application to violate the FOCD provision.[29] Senator Alan Simpson wrote a letter to the NRC chairman seeking further explanation. Among other things, the letter inquired about the NRC's "standard for determining the degree of FOCD that would be inimical to the common defense and security or pose an unreasonable risk to public health and safety." In reply, the NRC noted that the FOCD provision could not be overcome by a finding of noninimicality, and that the FOCD provision was an "entirely separate and absolute one." In other words, the NRC concluded that even if the application did not pose a risk to the common defense and security of the United States, it still violated the FOCD provision.

The NRC also noted in its response that to approve a license that did not pose a threat to interests of the United States, but nonetheless contravened the FOCD provision, Congress would need to amend Sections 103d and 104d, and that "as a general proposition the Commission would not oppose added flexibility in this area." In response, Congress passed a law that allowed the NRC to approve only the specific Cintichem transaction "notwithstanding" the FOCD provision, as long as the NRC determined that the "transfer would not be inimical to common defense and security or to the health and safety of the public."[30] Thereafter, the NRC authorized the transfer of the research reactor license to Cintichem subject to specified conditions.

The case of Cintichem reflects NRC and congressional recognition nearly 40 years ago that the FOCD provision might be antithetical to the interests of the United States. As a result, Congress took action—in this one case—to allow the research reactor facility in question to avoid the FOCD requirement because the Swiss ownership was determined not to be inimical to the interests of the United States. The Cintichem case stands in stark contrast to the two examples discussed below, which involved more recent power reactor license applications.

South Texas Project, Units 3 and 4

In 2007, the STP Nuclear Operating Company (STPNOC) applied to the NRC for a combined license to build and operate two new power reactors at an existing nuclear power station located southwest of Bay City, Texas. STPNOC, a subsidiary of US-based NRG, already owned and operated the operating plants STP Units 1 and 2. In 2011, Nuclear Innovation North America, LLC (NINA) became the lead applicant for the application, with STPNOC remaining as the operator. NINA was 90 percent owned by NRG and 10 percent owned by

Toshiba American Nuclear Energy (TANE), a US subsidiary of the Japanese company Toshiba Corporation. The two new units were to be Advanced Boiling Water Reactors (ABWRs) of the type already built and operating in Japan.

Due to the 10 percent indirect investment from a Japanese corporation, the applicants created a NAP to address FOCD restrictions.[31] The NAP required that three out of the four members of the board of directors for the project must be US citizens and that two members must be "independent" (that is, they could not be employed by NINA, its subsidiaries, owners, or affiliates). The NAP further required the creation of a Security Committee that would include the chairman of the board and the two independent directors and decide all matters relating to nuclear safety, security or reliability. In addition, the NAP required creation of a Nuclear Advisory Committee made up of independent US citizens with experience in nuclear safety and national security. That committee would advise and make recommendations to the NINA board on its ongoing compliance with the FOCD restrictions and that could alert the US government to any potential noncompliance issues.

The American company participant, NRG, initially provided 90 percent of the costs of the project but, toward the end of the NRC's review of the combined construction and operation license, ultimately decided not to make further investments toward obtaining the power reactor license due to less favorable economic conditions (e.g., a decrease in natural gas prices). Because the project was relatively close to obtaining a construction license from the NRC, and as it was a comparatively smaller amount of money left to obtain the license, Toshiba indicated that it was interested in completing the licensing activities.[32] NRG assented as Toshiba would be funding the majority of the limited remaining work to complete the NRC licensing process. Of note, the license could be used at a later time if natural gas prices rose or climate policies (e.g., a cap-and-trade bill) were enacted.

However, NRC staff and interveners[33] argued in 2011 that this arrangement was prohibited by the FOCD statute. NRC staff took the view that since Toshiba was funding the majority of the remaining licensing work, this ran afoul of the statutory and regulatory FOCD prohibition, even if it was still a small percentage of the overall project costs. The issue was later taken up by the Atomic Safety and Licensing Board (ASLB) in a hearing on the contention. As an NRC staffer stated before the ASLB, the FOCD contention was "holding up a licensing decision."[34] During the same hearing, the staffer was asked if anyone at the NRC disagreed with the finding and, as part of the answer, admitted that there was "a lot of points of view" and "varying views" at the NRC.

The NRC staffer further testified that she was not aware of anything about the South Texas Project that was inimical to the national defense and security interests of the United States, any concerns about the country in question (Japan), or any nonproliferation concerns.[35] Finally, the NRC staff also acknowledged that the proposed NAP, among other things, put nuclear safety and security decisions exclusively in US hands.

During the same ASLB hearings, a former director of nuclear reactor regulation at the NRC testified that the NAP that NINA had put in place conformed to NRC precedents and that he personally would "not have had a concern with the STP Units 3 and 4 project satisfying the FOCD requirements if I still were the director of NRR."

The ASLB ultimately determined that the interveners and NRC staff were wrong and ruled in favor of NINA on April 10, 2014.[36] But the contested application of the FOCD provision in this case resulted in increased costs as well as considerable delay and uncertainty in the NRC licensing process—clear disincentives to future foreign investment in reactor licensing projects. The example in South Texas involved a close US ally pouring money into a US project that would have created high-paying jobs and carbon-free, dispatchable energy. It involved a reactor design the Japanese themselves had built multiple times previously. As the NRC staff conceded, the Japanese investment in a US reactor project did not present any "inimicality" issues under the AEA. Yet, for nearly three years, the uncertainty over how the FOCD statute would be interpreted and applied hung like a cloud over the project, despite the lack of any perceived, much less demonstrated, threat to US safety or security.

UniStar Nuclear Operating Services, LLC (Calvert Cliffs Unit 3)

In 2007, UniStar Nuclear Operating Services submitted a combined license application to build and operate a third reactor at the existing Calvert Cliffs nuclear power plant site.[37] UniStar was a US entity pursuing the construction of a French-designed reactor, the EPR. When the application to build Unit 3 was submitted to the NRC, UniStar was a 50/50 venture between a US company, Constellation Energy Group, and a French company, Electricite de France (EDF). However, a group of interveners[38] challenged the project in 2008 on FOCD grounds, asserting that EDF also owned 9.51 percent of Constellation, pushing foreign ownership above 50 percent.[39]

In 2010, EDF had purchased Constellation's interest in UniStar, thereby making UniStar 100 percent indirectly owned by a French entity. To address FOCD concerns, a NAP was submitted to the NRC that required the board of directors for UniStar to have four members, with two directors required to be US citizens and "independent" (that is, they were to have no affiliation with UniStar or EDF). The chairman of the board was also required to be a US citizen. These three US citizens would form a Security Committee with "exclusive authority" to decide matters of nuclear safety, security, or reliability. In addition, the NAP provided that a Nuclear Advisory Committee (NAC) would be created to advise and make recommendations to the board of directors on compliance with FOCD. The NAC would be composed of independent US citizens experienced in nuclear safety and national security and would be able to notify the US government of any potential noncompliance issues.

On August 30, 2012, the ASLB agreed with the interveners' contention that UniStar was ineligible to obtain a power reactor license on account of the FOCD provision.[40] The ASLB found that the 100 percent indirect ownership of the projects by a French entity could not be overcome by mitigating control and domination aspects and rejected the license application.

According to the SECY-14-0089, "Under the current NRC interpretation of the FOCD provision, the Commission has the discretion to approve licenses up to, but not including, 100 percent foreign ownership; at the present time, there is no bar to the approval of 99 percent foreign ownership, although the Commission has not yet been asked to rule on a matter involving 50 to 99 percent foreign ownership." Thus, the rejection of Calvert Cliffs Unit 3 on the basis of 100 percent indirect foreign ownership in theory could have been permissible if the French investment had been for 99 percent instead. This possibility is not certain, however, as it has not been tested in practice, and for reasons discussed below would almost certainly be challenged by interveners.

The difference between 99 percent and 100 percent indirect ownership appears to be a relatively immaterial difference in terms of practical import and implications for US security. Similar to the South Texas Project case, the discussion surrounding FOCD matters in the UniStar case devolved into a legal debate on interpreting a statutory provision from 1954, rather than whether the projects were inimical or not to the interests of the United States. As in the South Texas case, the FOCD uncertainty hung over the project for years, and the Calvert Cliffs project would have been funded by a close US ally. If built, the reactor would have created high-paying jobs and carbon-free, dispatchable energy. It is difficult to see how the investment by a French company itself would have been inimical to the interests of the United States.

The Failed 2014 NRC "Fresh Assessment"

The ASLB decision on UniStar was appealed to the commission, which denied the appeal on procedural grounds without reaching the merits of the ASLB's decision.[41] However, in its ruling, the commission noted at the same time that "with the passage of time since the agency first issued substantive guidance on the foreign ownership provision of the AEA section 103d., a reassessment is appropriate." The commission later issued a Staff Requirements Memorandum in 2013 that directed the NRC staff to perform a "fresh assessment" on issues related to foreign ownership, including recommendations.

In response to this policy directive, the NRC staff submitted a document in 2014 to the commission, titled "Fresh Assessment of Foreign Ownership, Control, or Domination of Utilization Facilities" (SECY-14-0089). In drafting SECY-14-0089, the NRC staff "performed a thorough review of the legislative history, statutory requirements, current regulations, and implementing guidance associated with FOCD, and engaged a wide range of stakeholders."

In the end, the SECY paper provided six policy options to the commission and recommended one (Option 3) in particular:

1. Maintaining the status quo
2. Proposing a legislative amendment to the Atomic Energy Act
3. Revising the guidance in the staff's FOCD Standard Review Plan (SRP) and developing an associated FOCD regulatory guide to provide a graded approach
4. Using alternative procedures to address FOCD
5. Redefining in guidance the statutory term "owned" to mean direct ownership only
6. Establishing bright-line determinations and safe harbors that set specific thresholds for acceptable levels of FOCD based on percentage of foreign ownership

The commissioners' divergent responses to the SECY document are telling and reinforce the problems inherent in the FOCD provision. Two of the commissioners (Ostendorff and Svinicki) approved of option 5, to reinterpret the FOCD provision to allow for 100 percent indirect ownership, but not allow direct ownership. Commissioner Svinicki in particular viewed the distinction between 99 percent indirect ownership and 100 percent indirect ownership as relatively meaningless.[42] Chairman Burns, the NRC's former general counsel, felt that allowing just one more percent (99 percent to 100 percent) would represent a major change to the NRC's legal interpretation of the AEA and thus was not supportive of such a change. Commissioner Baran took a very different view than the other three commissioners, arguing that even 99 percent indirect ownership was illegal, and that majority indirect ownership by a foreign entity was prohibited by law.

Commissioner Baran interpreted the words "ownership, control, and domination" to be "separate and distinct restrictions" such that "abatement of control and domination cannot make up for majority foreign indirect ownership." He concluded that "advocates for more foreign ownership and investment in US nuclear reactor projects should take their case to Congress if they view the FOCD provision as a barrier to such investment." The other commissioners disagreed, however, with Commissioners Ostendorff and Svinicki looking at the "FOCD provision as a whole, focusing on national defense and security."

Thus, the vagueness of the FOCD provision has continued to plague the NRC even in recent years, with commissioners reaching widely disparate views about the nature (i.e., direct versus indirect) and percentage of foreign ownership permitted by the FOCD provision. The NRC's "Fresh Assessment" from 2014 has unfortunately failed to bring greater regulatory clarity to the public and the industry as to what is and is not permissible with regards to nuclear energy cooperation involving even some of the United States' closest allies. The commission's split decision means that future decisions may be decided inconsistently with past decisions (depending, in part, upon the commission's makeup). It also sows the seeds for future litigation and creates more uncertainty for applicants, other stakeholders (including investors and the general public), and the ASLB. As one review paper opined, "The Commission's split decision nearly guarantees that this question will again come before them, and from there review may be sought in a Federal appellate court. The NRC's approach to the FOCD provision also leaves open the possibility that an appellate court could overturn the entire scheme on judicial review."[43]

As part of the "Fresh Assessment," the staff recommended option 3, which was to revise the FOCD Standard Review Plan (SRP) and develop regulatory guidance. A draft SRP and draft regulatory guidance were published in 2016, but neither appears to have been finalized.[44] The SRP is not legally binding, however, and does not resolve questions over the legal interpretation of the FOCD provision. While both the draft SRP and draft regulatory guidance discuss indirect ownership above 50 percent and up to 99 percent (or less than 100 percent), interveners may be emboldened to challenge this possibility given Commissioner Baran's differing legal interpretation of the FOCD statute that this possibility is legally impermissible. This could result in future litigation and further deter investment in nuclear energy projects by US allies.

Absent a congressional fix, the FOCD provision could continue to present challenges to future advanced reactor projects. Indeed, the recent cases described above involved some of the United States' closest allies, and that would likely be the case again in the future. For example:

- If the company URENCO wanted to deploy its U-Battery in the United States, it would not be able to do so if it was the sole funder of the project or potentially as a majority investor. Even as a minority investor, it might still encounter hurdles and potentially be subject to a NAP, with the associated burdens and the uncertainties as to what provisions in the NAP will be acceptable to the NRC. The South Texas Project case discussed above is illustrative—contentious hearings before the ASLB proved necessary even though the Japanese entity Toshiba held a mere 10 percent interest in the project.

- If Canadian investors wanted to build a molten salt reactor design at Idaho National Laboratory using the Canadian company Terrestrial Energy's design, they would likely encounter the same obstacles.
- The APR1400 reactor design from the ROK was recently certified by the NRC, but ROK investment in such a project in the United States would be subject to FOCD restrictions and the associated uncertainties.
- Finally, reports have discussed the possibility of investment from the ROK to finish the AP1000 builds in South Carolina.[45] The FOCD provision could again act as a barrier against South Korean investment.

In addition to the mutual defense agreements described in chapter 1 that bind the United States and its allies to each other's defense, the United States also has agreements to share classified intelligence with small groups of countries (e.g., the "Five Eyes" alliance that includes Canada, the UK, New Zealand, and Australia), where the countries discuss, among other things, how to counter Chinese influence and investments.[46] In the case of the UK, the United States even has an additional mutual defense agreement in place to share classified nuclear weapons information with the British government.[47]

Thus, it is difficult to apprehend why UK and Canadian investment in US nuclear energy projects would somehow be inimical to US interests. As Paul Murphy, a financing expert, stated to the NRC, the reason these rules matter is that "they limit (via constraint and confusion) our financing options, when [nuclear power plant] financing is the greatest challenge to [nuclear power plant] development."[48] This is in large part due to the total amount of money needed for a nuclear power plant, as the case study discussed in chapter 3 illustrates. Mr. Murphy further noted that vendor equity has become a key trend in nuclear power plant development around the world, citing examples in the UK, Turkey, and Finland.

The South Texas and Calvert Cliffs reactor projects would have been challenging for other reasons (e.g., the drop in natural gas prices, the costs associated with getting a DOE loan guarantee, etc.). However, if the United States ever has a federal climate policy—or if substantially more states enact or pursue decarbonization policies—investment from US allies would be helpful. Greater cooperation with US allies could also help to preserve a role for the United States in the international nuclear energy regime, in furtherance of US national security interests. As former US Deputy Secretary of Defense John Hamre stated to the NRC in 2015, "If America shrinks from the commercial nuclear energy field, we will lose the power to shape the global non-proliferation regime . . . . Preventing the spread of nuclear weapons depends on America remaining a global leader on commercial nuclear energy. Foreign companies are now integral partners in our commercial nuclear enterprise."[49]

The next subchapter discusses a legislative fix to the FOCD problem that the NRC first proposed to Congress over 20 years ago to recognize the changes that had taken place in international nuclear energy markets since 1954.

Back to the Future: The 1999 NRC Legislative Proposal

In 1999, the NRC submitted several legislative proposals to the US Congress.[50] One proposal was to amend the FOCD language in Sections 103d and 104d of the AEA.[51] The specific proposal was to repeal the FOCD provision for power and research reactors, while retaining it for production facilities; in both cases, the inimicality provision would be retained.

Legislation was introduced that year in response to the NRC proposals, including the FOCD amendment.[52] During several hearings held that year and in subsequent years, the proposed FOCD amendment was discussed.[53] The NRC's position was that the FOCD language in Section 103d was anachronistic given the differences between the global nuclear power regime in 1954 versus nearly half a century later. The NRC argued that any legitimate foreign ownership concerns could be addressed through the inimicality determination required by the sentence immediately following the FOCD provision in 103d (i.e., the FOCD restriction is superfluous). Specifically, at a 1999 hearing, the chairman of the NRC, Greta Joy Dicus, testified that the restrictions had been enacted during a time when commercial nuclear power development was in its early stage, but that the present-day situation had changed significantly, where commercial use of nuclear power had become common and the underlying reactor technology was widely known.

In response to written questions following the hearing, the NRC further explained that it had forwarded the legislative proposal on amending the FOCD provision to the Office of Management and Budget (OMB) at the White House for the purposes of gathering Executive Branch views. OMB provided the legislative proposals to the US Department of Defense, the US Department of Justice, the US Department of State, the US Department of Energy, and the National Security Council. Significantly, none of these entities objected to the proposal to eliminate the foreign ownership restriction.[54]

In addition, the NRC went on to say in its answer to Congress that it believed that the noninimicality restrictions in Sections 103d and 104d provided "ample authority" for the NRC to refuse a license or take other actions if a particular ownership arrangement was inconsistent with US security. The NRC noted that other domestic sources of energy supply do not have the same restrictions on foreign ownership and called the provisions "outdated and unnecessary" as the nuclear industry, "like most high technology industries, has for some time been an international enterprise." The NRC observed that other categories of reactor vendors, construction firms, fuel cycle facilities, spent fuel cask manufacturers, and reactor component manufacturers have significant foreign ownership and asserted that commercial nuclear plants should be "treated similarly."

In 2000, Senator Pete Domenici introduced a bill that contained the NRC's proposal on FOCD and argued that the FOCD provision was a "significant obstacle to the foreign investment or participation in the US nuclear power industry."[55] At a Senate Environment and Public Works Committee hearing in 2000,[56] NRC Chairman Richard Meserve testified that the provisions were not needed and that "we are confident . . . that no inappropriate foreign entity . . . would ever pass muster under the revised statute."

In 2001, the NRC again sent the same legislative proposal on amending the FOCD statute to Congress.[57] At a May 2001 US Senate hearing, NRC Chairman Richard Meserve testified again that "elimination of the ban on foreign ownership would be an enhancement since many of the entities that are involved in electrical generation have foreign participants, thereby making the ban on foreign ownership increasingly problematic."[58]

Notably, it appears that when the NRC legislative proposal on FOCD has been introduced in legislation, it has been subsumed in much larger nuclear-related bills. It does not appear that these larger bills introduced in 1999, 2000, and 2001 were ever voted on the floor of either the US Senate or the US House of Representatives, and the FOCD amendments themselves were never voted on separately on the floor of either chamber or within any congressional committee.

As part of the 2014 "Fresh Assessment" discussed in the previous subchapter, the NRC staff considered proposing a legislative amendment to Congress again to remove utilization facilities from the FOCD provision as part of Option 2. The NRC staff listed the following advantages and disadvantages to this approach:

Advantages:

- It would clearly recognize the global capital markets for new commercial nuclear power plants.
- The elimination of foreign ownership reviews could streamline licensing reviews in some cases.

Disadvantages:

- Prior efforts at legislative change have not been successful; thus, the probability of a legislative change occurring is questionable.
- The staff would still be required to make an inimicality finding and, in certain instances, the legislative change may not result in a shortened licensing review.

This report contends that the advantages to the legislative option are different and also of greater value than the NRC staff seem to estimate, and moreover the disadvantages cited by NRC staff are largely irrelevant. A streamlined licensing process is implicitly seen as the desired outcome by the NRC staff, but this is not the end goal. Rather, what is needed is a statute that provides the clarity and flexibility to handle national security issues in a modern-day context and based on the individual countries involved. Simply put, the law should not treat investment from the UK or Canada the same as investment from China or North Korea. That the 1999 NRC legislative proposal never passed into law is also irrelevant. Again, Congress does not appear to have ever considered the proposed FOCD amendment separately from larger nuclear bills. Furthermore, in the intervening 20 years, the case for amending the FOCD statute has grown even stronger. Since that time, the FOCD statute has been problematic on multiple occasions (e.g., the South Texas and Calvert Cliffs examples above) and divergent legal and policy views on the FOCD provision have emerged at the commission level (the commissioner votes following the "Fresh Assessment"). These issues have all occurred many years after the NRC had publicly identified to Congress—two decades ago—that the FOCD statute was "increasingly problematic" and proposed a legislative fix.

Additionally, since 1999, the trend toward increased globalization of the nuclear energy supply chain has continued, causing the United States and its allies to be even more dependent on one another for nuclear services, components, and materials. The canceled and over-budget AP1000 projects in the United States and the Westinghouse bankruptcy have heightened the need for cooperation with US allies. US nuclear projects will likely depend more than ever on financial investment, expertise, and component supply from US allies. The rising challenge of Russian and Chinese dominance of the international nuclear energy marketplace is an additional development since the late 1990s that further reinforces the need for FOCD reform.

The 1999 NRC legislative proposal to amend the AEA is not unique—there are precedents for removing statutory constraints on FOCD in analogous contexts. For example, the Solar, Wind, Waste, and Geothermal Power Production Incentives Act of 1990 included an amendment to the AEA to remove US uranium enrichment facilities from the AEA definition of a "production facility," thereby exempting such facilities from application of the AEA's FOCD restriction.[59] For example, the URENCO LES enrichment facility in New Mexico, which utilizes sensitive gas centrifuge technology, is 100 percent indirectly owned by UK, German, and Dutch entities. While it was never built, the NRC also issued a license to AREVA, a French company, to build an enrichment facility in Eagle Rock, Idaho. These are striking examples of differences in US law: US allies are allowed to have 100 percent indirect ownership of an enrichment facility in the United States, but not a power reactor facility.

In the case of URENCO, the company is bringing classified information to the United States for the gas centrifuge facility in New Mexico. This facility provides high-paying US jobs and a valuable service to the US electricity sector, and it is an example of where the United States has found a way to balance sensitive national security concerns with global economic cooperation because in the case of enrichment facilities, there is the legal flexibility to do so, and the foreign entities involved are from close US allies.

Handling Foreign Investment Using the Inimicality Determination and an Example from the US Defense Sector

The heart of the FOCD problem is that the statute is country blind and cannot distinguish friend from foe. The draft regulatory guide for FOCD states[60] that the provisions are "country neutral," whereas the inimicality review accounts for an applicant's "country of origin and any ties or interests" that are pertinent to US security.

The draft FOCD SRP even notes that reviewing applications for FOCD matters is not about whether the project itself is in the interests of the United States or not.[61] Ironically, the country-neutral nature of the FOCD statute means that it does not prohibit investment from Chinese or Russian origins where there would actually be inimicality concerns.

One positive outcome from the 2014 "Fresh Assessment" is that it appears to have indirectly led to more modernized thinking on the part of the NRC regarding the inimicality determination and foreign involvement in the licensing of utilization facilities. In 2015, the commission approved the staff's recommendation from the "Fresh Assessment" to revise the FOCD Standard Review Plan and develop a regulatory guide that included graded NAPs.[62] The same memorandum directed the NRC staff to provide a SECY paper to the NRC on options for performing formalized inimicality reviews, including specifically foreign interests involved in the licensing of utilization facilities. The resulting SECY-16-0056 document proposed a process for inimicality reviews of foreign interests, including (but not limited to) the following steps:

- Conducting a corporate analysis to determine if an applicant or licensee has ties to foreign entities
- Implementing a screening process to identify countries for which there are bans related to activities with those countries
- Conducting an analysis of the ties between the applicant or licensee and foreign entities and their associated countries, which includes inquiries to the intelligence community, to determine if those foreign interests are inimical to the common defense and security of the United States

As part of the proposal, the NRC staff suggested a screening process to identify foreign entities that are not inimical to the common defense and security of the United States. The specific criteria used were 1) a mutual defense treaty, and 2) an AEA section 123 agreement, both of which involve previous determinations made by the Executive Branch related to national security.[63] For countries that met these criteria, and which NRC had not identified derogatory information on earlier in the review process, the entity would be screened out of the review process as not inimical to the common defense and security of the United States.

Conversely, as SECY-16-0056 states, "there are a small number of countries, and foreign corporations and entities associated with those countries, whose direct or indirect involvement with an NRC licensee would pose an unacceptable risk to the common defense and security of the US, no matter what level of security measures were implemented to address that risk." This flexibility to identify allies of the United States and to differentiate them from entities whose involvement would be inimical to the interests of the United States is the crucial modernization that the NRC needs moving forward. However, since its publication, the SECY-16-0056 document does not appear to have moved forward in terms of a policy vote, and the FOCD statute persists in its current form.

One example that the NRC could consider in assessing its approach to foreign investment in power reactors—specifically how to balance economic and national security concerns—comes from the United States defense sector. In US Department of Defense (DOD) terminology, the relevant term is slightly different (FOCI—"foreign ownerships control or influence"), but DOD must also balance the value of foreign investment with protection of US security. The associated risks in the defense world include sabotage, espionage, unauthorized access to US IP, export control violations, diminished supply of product in US market, and foreign control of critical product/industry. The US military uses FOCI mitigation instruments akin to NAPs that include broad resolutions, security control agreements, special security agreements, and proxy agreements and voting trust agreements.[64] Unlike the FOCD provision's impact on US policy, however, official US defense policy is actually aimed at *facilitating* foreign investment in the defense industrial base. For example, the National Security Program Operating Manual ("NISPOM") notes that "foreign investment can play an important role in maintaining the vitality of the US industrial base" and that "it is the policy of the US Government to allow foreign investment consistent with the national security interests of the United States."[65]

The US defense sector has even been able to manage US government security clearances at foreign-held companies.[66] This report posits that if the US defense sector can find a way to facilitate foreign investment and involvement without compromising US security, then Congress and the NRC should be able to balance investment from US allies in nuclear energy projects while protecting US security. As Stan Stims, director, Defense Security Service, US Department of Defense, stated to the NRC, "We live in a world that increasingly consists of global supply chains, and we need to think in more sophisticated ways on how to determine what constitutes genuine risk . . . If we take an absolute approach to any one FOCI factor, we risk shutting out the potential for valuable contributions some companies can make to our national defense."[67]

In a similar statement to the NRC, former US Deputy Secretary of Defense John Hamre added that in the defense world "we do not take a single dimension—like percentage of foreign ownership—and build security policies only around that dimension. That would be a huge mistake … The Commission needs to develop a sophisticated approach to determining real vulnerability and risk, and not rely on simplistic formulas of foreign ownership."[68]

If the FOCD restriction were directed solely toward production facilities, as the NRC has proposed, NRC's review of power reactor applications would be focused on its inimicality finding and would allow for a risk assessment of foreign entities. Close allies such as the UK and Canada should be given a greater opportunity to invest in US reactor projects, while countries such as Russia and China should be blocked from even comparatively small investments. In other words, the NRC should examine how other parts of the US government handle foreign involvement and investment on a case-by-case basis and recognize close geopolitical alliances.

There are other regulatory contexts in which the US government distinguishes among individual countries, bestowing favorable consideration upon its allies. For example, DOE has identified a list of countries that it has generally authorized unclassified nuclear energy assistance to in the appendix to the 10 CFR Part 810 regulations. Likewise, in 10 CFR Part 110.26, the NRC has published a list of countries to which minor reactor components may be exported under a general license. Finally, the US Department of Commerce's Export Administration Regulations contain a country chart that lists which countries (e.g., China) require a license for export from the United States of certain dual-use items that are controlled for nuclear nonproliferation reasons; US companies are not required to submit license applications to export these items to close US allies.

An Additional Safeguard Put in Place after 1954: CFIUS

Another important consideration is that the Committee on Foreign Investment in the United States (CFIUS) did not exist when the AEA was enacted in 1954. CFIUS was established by Executive Order in 1975, and the process CFIUS used to review foreign investment transactions was first codified into law in 1988.[69] The underlying statute authorizes the president (through CFIUS) to review "any merger, acquisition, or takeover ... by or with any foreign person which could result in foreign control of any person engaged in interstate commerce in the United States." CFIUS thus must evaluate the impact on US national security from covered transactions. The president may suspend or prohibit a given transaction, or impose conditions on it, if there is a risk to US national security. CFIUS is chaired by the secretary of the treasury, and additional members include the secretaries of defense, state, homeland security, energy, and commerce; the attorney general; the director of national intelligence; and others.[70]

The United States generally welcomes foreign direct investment, and America is actually the top recipient of foreign direct investment in the world.[71] A common result in CFIUS matters that are determined to raise national security concerns is for the government to conduct "mitigation," where security and reporting conditions are placed on transactions (see 50 USC. 4565). This is somewhat similar to the NRC's NAPs. The default in CFIUS is that foreign investment is permitted provided it does not raise any national security concerns, and, generally, CFIUS looks to resolve all national security concerns identified in a covered transaction through mitigation measures rather than referring the transaction to the president to block it.

In CFIUS, a "covered transaction" is one that can result in control of a US business. From 2015 to 2017, China, Canada, Japan, the United Kingdom, and France were the top five countries in decreasing order of the number of transactions reviewed by CFIUS.[72] CFIUS reviews and mitigation agreements must involve risk-based analysis. The end results of CFIUS actions are not generally country neutral (e.g., China is not treated the same as Canada).

Thus, a company trying to acquire or build a power plant in the energy sector may be subject to a review by CFIUS to identify any national security implications of the foreign investment. CFIUS scrutiny of nuclear transactions was recently strengthened when the Foreign Investment Risk Review Modernization Act of 2018 (FIRRMA) was passed as part of the National Defense Authorization Act for Fiscal Year 2019. FIRRMA expands the scope of covered transactions subject to CFIUS notice requirements and increases scrutiny of foreign investments involving "critical technologies," including nuclear technology.

The next chapter discusses an investment the South Korean company Doosan Heavy Industries & Construction (DHIC) made in the US reactor company NuScale Power in 2019. This transaction underwent a CFIUS review, and if the federal government had determined that the investment entailed risk to US national security, the investment would have been subject to mitigation or would have been blocked.

CASE STUDY ON NUSCALE POWER DEVELOPMENT COSTS AND BENEFITS TO COOPERATION

Nuclear energy reports in the past have looked at the construction costs of new nuclear plants.[73] The development costs that private companies incur on the way to a final power plant design have received less attention. One of the problems for the AP1000 builds in the United States was that the plant construction commenced before design completion.[74] This chapter looks at one case study on the development costs for the first-of-a-kind engineering, testing, licensing, and other work necessary to reach a complete design *before* construction starts. As the case study demonstrates, the development costs involved in bringing a new advanced reactor to market can be substantial, further underscoring the need for the United States and its allies to work together to minimize development costs and diversify available sources of funding. Specifically, NuScale Power has benefited from partnerships with entities in France, the United Kingdom, and the ROK—three US allies.[75]

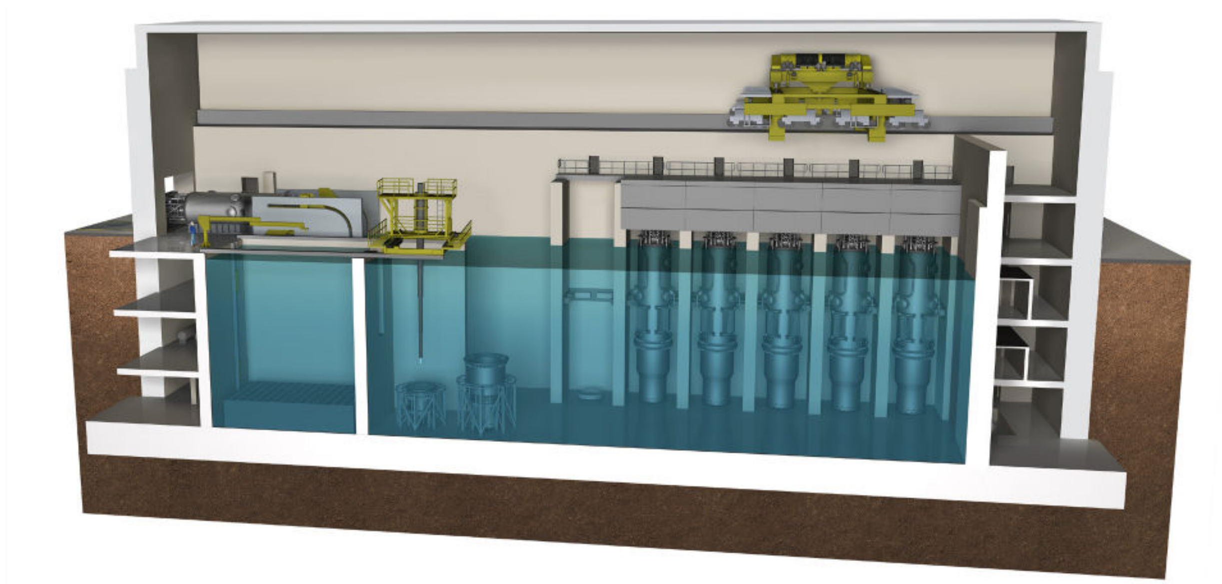
The Nuclear Energy Research Initiative and Enhanced Passive Safety

NuScale Power was born out of R&D work that DOE funded nearly two decades ago to a team from Oregon State University, Idaho National Laboratory, and Nexant (a consulting subsidiary of Bechtel) for a three-year project called the Multi-Application Small Light Water Reactor (MASLWR).[76] Enhanced passive safety features were a major thrust of the study. For reactor safety analysis, decay heat from irradiated nuclear fuel has to be safely managed so that the fuel and the cladding around it do not melt/rupture in an accident scenario. Containment structures are also designed to prevent the release of radioactive elements to the biosphere.

The concept in the MASLWR report was that the residual heat from spent nuclear fuel rods could be managed even in extreme circumstances, such as station blackout (e.g., the conditions that led to the accident at Fukushima Daiichi, where no on- or off-site power was available), and not be dependent on operator action. The approach used a plant design where the reactor modules relied on gravity (as opposed to electrically powered pumps) to circulate the coolant, and the modules themselves were all submerged in one large pool of water. This approach allowed residual decay heat from used fuel rods to be passively transferred from the fuel rods to the coolant and out to the large pool without 1) action from the reactor operators, 2) the need for off-site power, or 3) the need for off-site water for cooling purposes.

For the pool that NuScale ultimately designed, the reactors could passively transmit heat to the pool for a period of approximately 30 days, during which time the pool water would slowly evaporate. At the end of those 30 days, the spent fuel rods would have cooled sufficiently to allow the reactors to passively transmit the residual heat to the air (i.e., utilize air cooling). A cutaway of the NuScale pool and reactor modules is shown in figure 4. In this manner, the reactor could indefinitely cool the spent fuel rods without the need for operator intervention, off-site electricity (or on-site diesel generators), or more water.[77]

Figure 4: Model view inside the NuScale Power reactor building



Source: NuScale Power, LLC

Estimated Development Costs

To date, NuScale estimates that approximately $900 million (as of December 2019) has been spent in bringing its reactor design to commercialization, out of an estimated total of around $1.4 billion. Table 1 shows estimates for how those development cost are broken down.

Table 1: Past and estimated future development costs for NuScale Power

Development activity	Cost
Design certification application preparation	$407M
Design certification application review	$145M
First-of-a-kind engineering	$67M
Standard design approval for nuclear power module (includes NRC fees)	$54M
Standard plant design	$141M
Design finalization	$312M
General and administrative	$282M
Total	$1,408M

Source: NuScale Power, LLC

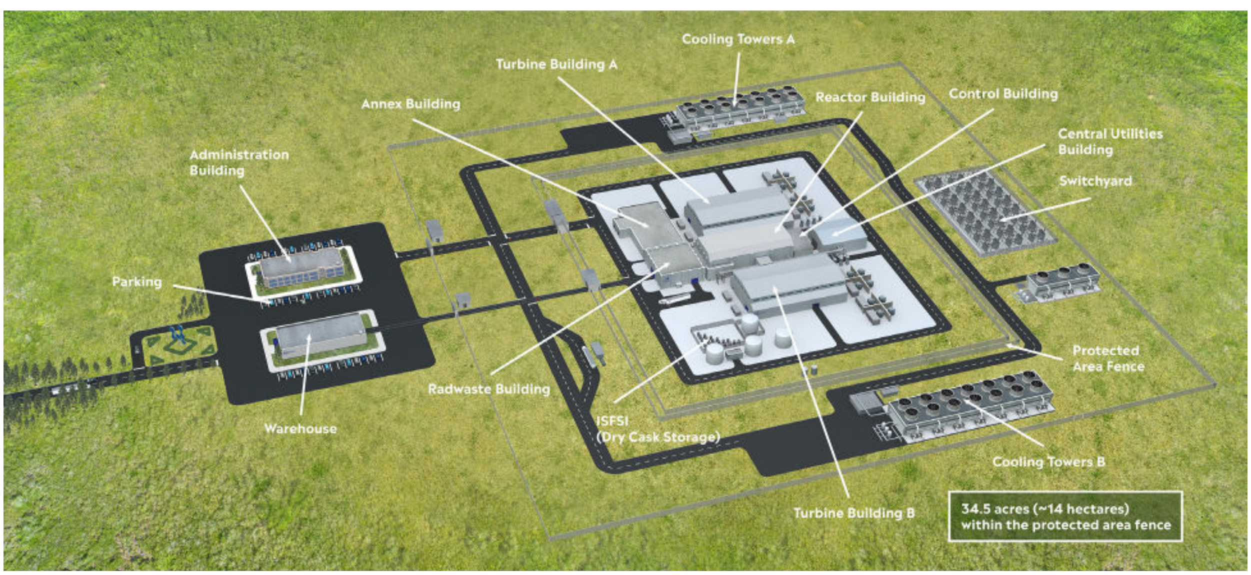
The first two entries include the work done between 2012 and 2016 to submit the design certification application to the NRC at the end of 2016, and the costs to support the NRC review of that application (including NRC fees) through to the issuance of a final safety evaluation report by the NRC, expected in 2020. The first-of-a-kind engineering costs include developing engineering solutions for new applications (e.g., a new type of valve). The standard design approval work includes the power uprate (i.e., moving from the initial design of 50 MWe per module to 60 MWe) that NuScale announced after submitting the design certification application to the NRC in 2016, as well as various other design improvements that have been made since that time. The general and administrative costs support the overall management and administration of NuScale, including accounting and finance, information technology, human resources, and executive management.

The two largest remaining costs for NuScale are standard plant design and design finalization. The first is to support as much engineering as will likely be repeated for all future plants, leaving only the engineering required that will be specific to each site. Design finalization is to finish work on the entire design including the nuclear power module in order to enable component manufacturing and final cost estimates of a standard NuScale plant design. This will facilitate the cost-effective and timely construction of a first-of-a-kind (FOAK) power plant, which typically costs more than later plants—otherwise known as "nth-of-a-kind" (NOAK).

Estimated Construction Costs for FOAK and NOAK Plants

The NuScale Power plant is 720 MWe gross (12 modules x 60 MWe per module) with a 683 MWe net output after accounting for electricity use at site. The power plant layout is depicted in figure 5.

Figure 5: NuScale Power plant layout



Source: NuScale Power, LLC

Using the labeled structures in figure 5, the estimated construction costs can roughly be broken down into several major categories:

- Reactor building: the building that houses the 12 reactor modules in the large pool, including the installation, concrete and metalwork, and other materials. Includes the cost of the reactor modules and their containment structures.
- Control building: located adjacent to the reactor building, it houses the plant's main control room and the technical support center, which is located below the main control room and outside the radiological controlled area. The technical support center provides space to support emergency operations and personnel.
- Radioactive waste (radwaste) building: located adjacent to the reactor building, this manages and processes radioactive waste for all 12 reactor modules. Specifically, it provides space for heating, ventilating and air conditioning equipment, radiation filtering equipment, radioactive waste treatment and storage equipment, and for servicing all potentially radioactive and nonradioactive tooling, fixture, and instrumentation.
- Turbine buildings A and B: on either side of the reactor building are two buildings that each house six power conversion systems (steam turbine generator, condenser, etc.), one for each reactor module. Steam lines from the reactor module travel to the turbine building to drive turbines to generate electricity. These costs include the installation, labor, and materials for concrete and structural metalwork for the building, as well as the turbine generators themselves and connected equipment.
- Balance of plant/site yard: the rest of the direct costs not in the categories above. Includes clearing, scraping, geo-technical work, drainage, fences, landscaping, and other activities. It includes all of the buildings and structures listed in figure 5 except for the buildings listed above (reactor, turbine, radioactive waste, and turbines) and does not include the administrative and training building, security building, and the switchyard, which are owner's costs.
- Field indirects: costs necessary to support the direct work above. They generally include temporary construction and consumables (e.g., supplies and materials used up during construction, including fuels, welding supplies, medical supplies), temporary facilities (office complex, field office trailers, toilet/changing trailers, warehouses, fabrication shops), weather protection, temporary roads, parking, fences, field staff (administrative, accounting, project management, project engineering, project controls, quality assurance, environmental), construction services, personnel testing, construction equipment and tools, craft burdens and benefits, and others.
- Home office: costs not typically incurred at the project site, involved in the conduct of everyday business, which can be directly assigned to specific projects, processes, or end products, such as engineering, procurement, expediting, quality assurance, training, document control, legal fees, auditor fees inspection, estimating, cost control, taxes, travel, reproduction, and communications.

Table 2 shows cost estimates for a first-of-a-kind (FOAK) 12-module NuScale Power plant at a generic, greenfield, southeastern US site. Table 2 also shows estimated costs for an Nth-of-a-kind (NOAK) plant. NuScale estimates price stabilization based on learning effects to occur at the eighth fabricated module (using the same vendor for fabrication) and the eighth plant built (using the same construction team).

Table 2: FOAK and NOAK construction cost estimates for NuScale Power plant

Component	FOAK plant cost	NOAK plant cost
Reactor building	$1,275M	$1,010M
Control building	$145M	$115M
Radioactive waste building	$90M	$70M
Turbine buildings	$325M	$260M
Balance of plant/site yard	$285M	$225M
Field indirects	$645M	$590M
Home office	$210M	$190M
Total overnight cost	$2,975M	$2,460M
$/kW	$4,350/kW	$3,600/kW

Note: Total overnight costs (2017$) do not include warranties, G&A, fees, contingencies, financing, escalation, and schedule risk.
Source: NuScale Power, LLC

Partnerships with and Investment from French, British, and ROK Entities

NuScale's SMR is an integral PWR, and the company has partnered with three entities from countries with long histories in reactor technology. As mentioned in chapter 1, cooperation between the United States and the ROK dates back many decades. US companies played a foundational role in the development of the ROK's nuclear energy program, where most of the PWRs in the ROK are based on US technology.[78] Companies located in the United States still supply the ROK's light water reactors with instrumentation and control equipment, pumps, and other components, and the ROK in turn supplies the United States with important equipment and services. One ROK company, Doosan Heavy Industries & Construction (DHIC) fabricated the reactor pressure vessels and steam generators for the Vogtle 3 and 4 AP1000 reactors under construction in Georgia. DHIC has also supported the APR1400 builds in the UAE, where it has supplied reactor vessels, steam generators, turbines, and generators for those reactors (US companies are also involved in those builds).

In 2018, NuScale and DHIC announced a collaboration agreement. As part of the agreement, DHIC would make a cash equity investment in NuScale with ROK financial investors, and DHIC would manufacture and supply key components for NuScale plants.[79] The two companies expect the value of the equipment supplied through the contract will total at least $1.2 billion. The cooperation would benefit both entities and advance the demonstration of NuScale's technology closer in terms of assembling the investment needed to reach a complete design and ensure that sufficient supply chain capacity and capability exists to support the initial NuScale nuclear power module orders. DHIC also has extensive experience in manufacturing specialized components for light water reactors.

France is also a US ally with a long history of nuclear energy cooperation on light water reactor technology with the United States. The PWRs in France also have their origins in US-demonstrated technology as part of the Atoms for Peace program. In 1981, the French government announced that it had agreed "amicably" with Westinghouse to end an agreement under which it had built reactors under license from Westinghouse. It further announced that Framatome (a company which is today majority owned by Electricite de France, which, in turn, is majority owned by the French state) would compete with US companies going forward for reactor business abroad.[80] Today, France produces nearly 75 percent of its electricity from nuclear power and is an important partner with the United States on nuclear energy matters.

Framatome owns a facility in Richland, Washington, that fabricates nuclear fuel for power reactors in the United States. The Framatome facility provides nuclear fuel for nearly one in four US reactors, or about 5 percent of total US electricity generation. In 2015, NuScale and Framatome (at the time, AREVA) announced an agreement to perform fuel design, testing, and analysis services using Framatome's existing light water reactor fuel technology.[81] Given the investment that Framatome had already made in these facilities, and in achieving NRC-licensed fuel, the collaboration saves NuScale from additional development costs and provides Framatome with future business. Under the agreement, Framatome would supply initial fuel loads for the first NuScale power plant, and also subsequent reloads.

The United Kingdom is another close ally of the United States. In 2018, about 19 percent of UK electricity came from nuclear energy, though the UK plans to shut down its indigenous gas-cooled reactors entirely by 2030, and is looking at new nuclear reactor construction projects which might include US companies. British companies such as Ultra Electronics have supplied components to many US nuclear power projects in the past. According to Ultra, "over 80% of all North American reactors rely exclusively" on its temperature sensors for critical reactor coolant monitoring, and over 20 percent of US nuclear power plants use its nuclear-qualified pressure transmitters for safety-related measurements.[82] Ultra and NuScale are partnered for design work on safety-related instrument and control systems in the NuScale power plant. Ultra Electronics became an investor in NuScale and a strategic partner in 2015.[83]

This case study is not to assert that every advanced reactor will have the same development and demonstration costs as NuScale Power. Microreactors, for example, would assuredly have much lower demonstration costs, and likely substantially lower development costs. The point is that substantial *development* costs can be involved in bringing a truly first-of-a-kind new advanced reactor through licensing and to design completion, in addition to the costs of *demonstration* (i.e., building the first reactor or even a somewhat smaller-scale reactor). The need to meet these substantial costs is another reason to deepen cooperation with other countries. NuScale's partnerships with ROK, British, and French entities have helped the company to assemble investment and keep development costs down along the way to design completion. The next chapter discusses how DOE might go about facilitating more of the same type of partnerships.

DOE INTERNATIONAL NUCLEAR ENERGY PROGRAMS AND ADVANCED REACTOR DEMONSTRATION

The DOE Office of Nuclear Energy has international programs that have carried out a variety of missions in the past two decades. However, several recent developments suggest the need for reconsideration and potential reorientation of these programs. With respect to climate change, the international community reached a historic agreement in 2015 to limit greenhouse gas emissions and aim to limit the impacts of climate change. That agreement has engendered commitments by entities in both the public and private sectors for greater investment in low-carbon technologies, which could include nuclear energy, depending on country-specific policies. In support of action on climate change, various states (e.g., California and Washington) have passed laws requiring their electricity supplies to be from zero-carbon energy sources by roughly midcentury.

Separately, the United States announced a large policy shift in 2018 that, in practical terms, means that it will not cooperate with China on advanced reactor development. As China is carrying out the largest new nuclear reactor build in the world, and many developers were considering either a first or subsequent build in China, this has substantially altered the planning of US advanced reactor companies.

This chapter discusses the ongoing Office of Nuclear Energy international programs and how they could be reoriented under the Paris Agreement, Mission Innovation, and the Breakthrough Energy Coalition to help facilitate greater nuclear energy cooperation between the United States and its allies on advanced reactor demonstration. In particular, such cooperation would better align with and could help to support US advanced reactor demonstration goals, including those found in the Nuclear Energy Leadership Act of 2019 and the recent Fiscal Year 2020 energy and water appropriations bill.

Ongoing DOE Office of Nuclear Energy International Programs

The Office of Nuclear Energy international programs carry out a variety of different functions, including participation in interagency efforts to support US civil nuclear exports and support for senior DOE missions involving the IAEA. The international nuclear energy efforts have also provided logistical support for bilateral nuclear energy R&D, as well as managing the implementation of existing multilateral and bilateral commitments. In particular, the Office of Nuclear Energy has initiated and supported multilateral fora in the past, including the two ongoing programs described below.

The Generation IV Forum

The Generation IV Forum was created in 2000 to be a collaborative international initiative in supporting the next generation of nuclear energy systems. It originally had nine members: Argentina, Brazil, Canada, France, Japan, the ROK, South Africa, the UK, and the United States. Later, several other states joined: Australia, China, Russia, and Switzerland. According to the Generation IV Forum website, the original meetings began in January 2000 when the DOE Office of Nuclear Energy “convened a group of senior government representatives from the original nine countries to begin discussions on international collaboration in the development of Generation IV nuclear energy systems." The Generation IV Forum identified six nuclear energy systems in 2002 for development: gas-cooled fast reactor, lead-cooled fast reactor, molten salt reactor, sodium-cooled fast reactor, supercritical water-cooled reactor, and the very high-temperature reactor.

Regarding US advanced reactor development, the author argues that it should be the characteristics of advanced reactors (e.g., economics, safety, waste generation) that should be the basis for considering their development, rather than identifying and limiting concepts under consideration by the coolant used, as the Generation IV Forum does. Deployment of advanced reactors is likely to be determined by economic factors, such as overnight costs, construction schedules, business models, and customer needs. Companies such as Holtec and GE, for example, are pursuing advanced reactors that use light water as a coolant, which exclude them from the Generation IV Forum. The Generation IV Forum also appears more focused on exchanges of progress made, rather than focused policy discussions on how to achieve reactor demonstration. The presence of China and Russia has additionally meant that the material presented by the United States at Generation IV meetings is essentially all open source. As the Charter for the Generation IV Forum International states: "To the extent practicable, the R&D fostered by the GIF should be open and non-proprietary."

International Framework on Nuclear Energy Cooperation

In 2010, the countries that were part of the previous Global Nuclear Energy Partnership agreed to transform the partnership into the International Framework on Nuclear Energy Cooperation (IFNEC). Similar to the Generation IV Forum, both China and Russia are members of IFNEC. As of April 2019, IFNEC had 34 participant countries. The executive committee meets annually and is composed of ministerial-level officials. There are three working groups:

- Infrastructure Development Working Group (IDWG). The IDWG supports the development of the infrastructure needed to ensure the highest standards of safety, security, and nonproliferation. Several areas have received particular attention: human resource development, radioactive waste management, small modular reactors, nuclear safety and regulation, nuclear security, and emergency preparedness and response.

- Reliable Nuclear Fuel Services Working Group (RNFSWG). The RNFSWG is focused on efforts to enhance reliable front- and back-end fuel services, while reducing the risks of proliferation. The RNFSWG has focused more on issues of spent nuclear fuel management, storage, and disposal in recent years.

- Nuclear Supplier and Customer Countries Engagement Group (NSCCEG). The NSCCEG analyzes the relationship between supplier and customer countries. It is focused on the following areas: safety, project development and financing, public acceptance, and accountability.

IFNEC is not focused on advanced reactor demonstration and has placed greater emphasis on the back end of the fuel cycle and nonproliferation considerations.

The 2015 Paris Agreement, Mission Innovation, and the Breakthrough Energy Coalition

Since the inception of the Generation IV Forum and the International Framework on Nuclear Energy Cooperation, there have been some important developments in terms of international climate and energy agreements.

The Paris Agreement

In 2015, world governments reached a landmark agreement (known at the "Paris Agreement") to reduce greenhouse gas emissions into the atmosphere, and to "accelerate and intensify the actions and investments needed for a sustainable low carbon future."[84] The Paris Agreement was built on the United Nations Framework Convention on Climate Change that entered into force in 1994 and aims to prevent "dangerous" human interference in the Earth's climate system.

The agreement identifies an aim to hold the increase in global average temperature to "well below" 2°C above preindustrial levels and pursue efforts to limit the temperature increase to 1.5°C. It also committed countries to prepare "nationally determined contributions" (NDCs) to reduce emissions, as well as to revise their NDCs in the future. According to the UN website, as of January 2020, 184 countries had submitted NDCs.[85] The agreement notes that "accelerating, encouraging and enabling innovation is critical for an effective, long-term global response to climate change and promoting economic growth and sustainable development. Such effort shall be, as appropriate, supported . . . for collaborative approaches to research and development."

In 2017, President Trump announced his intention for the United States to leave the Paris accord, and in 2019 the United States formally notified the United Nations that it would withdraw from the agreement.[86] That withdrawal would be complete in November of 2020 and would make the United States the only nation outside of the landmark climate accord. Future administrations would, however, be capable of rejoining the Paris Agreement.[87]

Mission Innovation

Mission Innovation was announced on November 30, 2015, as world leaders met to negotiate the Paris Agreement. The joint effort by the participating governments was intended to double clean energy research and development, though at the end of 2019, participating governments were not on track to accomplish this.[88] At the beginning of 2020, 24 countries and the European Commission were part of Mission Innovation. The Mission Innovation Action Plan that came out of the 2nd Ministerial meeting in 2017 identified four goals:[89]

1. A substantial boost in public-sector investment in clean energy RD&D at the national level of Mission Innovation members

2. Increased private sector engagement and investment in energy innovation, particularly in key Innovation Challenges

3. Many new or strengthened voluntary cross-border networks and partnerships on energy innovation, greater engagement from innovators, and accelerated progress in

addressing specific Innovation Challenges

4. Greater awareness among Mission Innovation members and the wider clean energy community of the transformational potential of energy innovation, the progress being made, and the remaining critical clean energy innovation gaps and opportunities

International statistics on advanced reactor RD&D by individual countries appear to be limited. As a related indicator, the International Energy Agency (IEA) collects total RD&D country spending from OECD countries on "nuclear," where the category includes work on reactors, waste management, fuel cycle, fusion, and other topics. Table 3 shows the top 12 IEA countries in terms of total RD&D spending on nuclear energy technologies.

Table 3: Top 12 IEA member country total RD&D spending on nuclear

Country	Total 2017 nuclear RD&D spending ($2018)
Japan	$1,151M
United States	$913M
France	$818M
Germany	$289M
United Kingdom	$232M
Italy	$129M
Canada	$108M
Belgium	$95M
Republic of Korea	$90M
Poland	$67M
Switzerland	$44M
Finland	$41M

Source: IEA, https://www.oecd-ilibrary.org/energy/data/iea-energy-technology-r-d-statistics_enetech-data-en

Breakthrough Energy Coalition

Also launched at COP21 in 2015, the Breakthrough Energy Coalition (BEC) is "an influential group of investors and institutions committed to developing reliable and affordable energy technologies that can help solve climate change. BEC believes that forging deep partnerships between its members and governments will lead to more investments earlier, and more energy solutions for more people faster." About a year later, BEC created Breakthrough Energy Ventures, which is an investor-led fund with more than $1 billion to create companies with business plans that would help mitigate climate change. BEC member Bill Gates noted that while the private sector knows how to build companies and evaluate the potential for success, governments play "an indispensable role in supporting energy research."[90]

The Breakthrough Energy Coalition has listed "Next-Generation Nuclear Fission" as part of its electricity technical quest.[91] The Bill Gates–backed advanced reactor company TerraPower has invested in two types of advanced reactors: a sodium-cooled faster reactor and a molten chloride salt reactor.

Along the lines of public investment (Mission Innovation) and private investment (BEC), the DOE Office of Nuclear Energy has proposed and managed cost-share programs in the past that utilized public-private partnerships. For example, DOE announced a partnership with TerraPower in 2019, with each entity contributing 50 percent of the cost toward an advanced fuel qualification methodology that would be submitted to the NRC.[92] The processes and methodologies described in the TerraPower work would be generally applicable to other fuel types and help other US companies to address the challenge of fuel qualification. The combination of increased public and private investment in advanced reactors could accelerate the availability of new zero-carbon options, with different economics, waste characteristics, output temperatures, and other features that would be useful in addressing climate change over the next few decades.

Recent Developments Regarding Congressional Legislation, China, and Russia

In view of the Paris Agreement and the creation of Mission Innovation and the Breakthrough Energy Coalition, a logical question that could be asked is: What are the United States and its allies going to do in order to demonstrate advanced reactors in a time frame that will make them relevant for addressing climate change in the coming decades?

One response has come from the US Congress in the form of legislation that has been introduced with broad bipartisan support in both the US Senate and the US House of Representatives.[93] The Nuclear Energy Leadership Act (NELA) requires, among other things, that the secretary of energy demonstrate "not fewer than two advanced nuclear reactor" projects by 2025, and establish a program to demonstrate "not fewer than two, and not more than five" advanced reactors by 2035.

The United States Congress has appropriated substantial amounts to clean energy technologies in recent years, including advanced reactor technology development. The Fiscal Year 2020 energy and water appropriations bill provided the US Department of Energy Office of Nuclear Energy $230 million for an advanced reactor demonstration program to demonstrate multiple advanced reactor designs, and another $141 million for reactor concepts research and development. The congressional language for the advanced reactor demonstration program states: "The primary goal of this new program is to focus Department and non-federal resources on actual construction of real demonstration reactors that are safe and affordable (to build and operate) in the near- and mid-term."

In addition to the international developments related to energy and climate change, there have also been major developments in the United States' relationships with China and Russia. While the Paris Agreement states that parties "shall strengthen cooperative action on technology development and transfer," for a variety of policy reasons, any meaningful US collaboration with China and Russia on advanced reactor demonstration has fallen by the wayside. In addition to the geopolitical considerations mentioned in chapter 1, at the end of 2018, the US government announced a new policy with respect to civil nuclear energy cooperation with China.[94] Under the 10 CFR Part 810 regulations, which govern unclassified nuclear energy assistance to other countries (e.g., nonpublic, proprietary nuclear reactor design information), there would be a presumption of denial for any license applications to China for

- Exports related to light water SMRs
- Non–light water advanced reactors
- New technology transfers after January 1, 2018
- Any transfer to China General Nuclear (CGN) and/or CGN subsidiaries or related entities

On the last bullet point, CGN was indicted by the US government for violating the 10 CFR Part 810 regulations in 2016 and remains under indictment. It is one of the largest nuclear companies in China, with many relationships to other Chinese entities, potentially complicating any advanced reactor work with even non-CGN companies. Thus, there would appear to be a large barrier to US advanced reactor companies working with Chinese entities.

This policy change had an immediate impact on US advanced reactor companies, some of which, given China's large domestic build market,[95] had planned to either pursue a first or subsequent build in China. For example, TerraPower had initially planned to build its first sodium fast reactor in China but has had to reconsider its strategy due to the new US government policy.

Russia is not a Mission Innovation member, and US nuclear energy cooperation with Russia has always had its own sensitivities. As opposed to China, Russia has never been seen by US advanced reactor developers as a potential market for deployment, and it has never built a US design inside its territory. Involvement with Russia in nuclear energy matters has been further complicated by nonnuclear geopolitical considerations in recent years. For example, President Bush had submitted a nuclear energy cooperation agreement with Russia to Congress in May 2008 but following the Russian military incursion into Georgia a few months later, the Bush administration withdrew the agreement from Congress. More recently, in response to Russian interference in the US elections in 2016, congressional legislation was introduced in 2017 that would have created new sanctions and, among other things, targeted Russian civil nuclear projects, provoking an angry response from Russia.[96]

Reorientation to Facilitate Greater Cooperation between the United States and Its Allies

A US advanced reactor demonstration program—along the lines of NELA or otherwise—would benefit from being able to draw on investment and other support from US allies. The large amounts of investment needed for design completion argue for increased efforts to keep developments costs low through shared use of facilities and expertise, and also to look for funding support from entities in allied countries.[97] There are several reasons why an allied government or private entities from that allied country might be willing to directly or indirectly support an advanced reactor demonstration in the United States:

- Subsequent builds in the allied country. The US Nuclear Regulatory Commission is still looked at as the gold standard of nuclear safety around the world. For that reason, another country may find it appealing for the NRC to analyze and license a first-of-a-kind reactor, and to provide regulatory oversight of its operation. This would provide a blueprint for the country's domestic regulator to license subsequent builds.[98]

  For example, Canada and the UK announced a global alliance to phase out coal electricity by 2030, removing one option for dispatchable electricity generation.[99] To reach deep decarbonization, Canada will need to find a way to replace that dispatchable generation with a zero-carbon resource without using traditional natural gas plants. As part of development efforts, the Canadian Nuclear Laboratories recently announced funding for collaborations with small modular reactor vendors to accelerate SMR design availability and enable access to the facilities and expertise at the Canadian Nuclear Laboratories.[100] One US company, Kairos Power, was one of the selected recipients. The partnership could help Kairos to limit its development costs by taking advantage of Canada's existing facilities and historical expertise on managing tritium, given Canada's long experience with its heavy water reactor fleet. Managing tritium production is an important design criterion for the fluoride high-temperature reactor that Kairos is pursuing, given the amounts of tritium produced by its molten salt coolant. Kairos has begun preapplication activities with the NRC to potentially build its first reactor in the United States,[101] but subsequent builds could include Canada. The Canadian government supported a roadmap on small modular reactor development that was published in 2019.[102]

- Economic gain through supplied content. Both the public and private sectors in a US ally may want to invest in a particular advanced reactor company headed for demonstration in the United States if they believe it will create economic value for their country or company in the initial build and subsequent build phases—even if the allied country never deploys the reactor in question in a domestic context.

  For example, as discussed in chapter 3, the ROK company Doosan Heavy Industries & Construction made an equity investment in NuScale Power, and consequently will have the right to supply key components for the reactor in future builds. Doosan and NuScale expect the value of the equipment supplied through the contract to be at least $1.2 billion. The agreement between the French-owned Framatome and NuScale, also discussed in chapter 3, would potentially create additional business opportunities for Framatome in terms of supplying fuel to NuScale plants in the United States, where it does not have an SMR of its own to compete. The agreement should also save NuScale development costs because Framatome already has a fuel fabrication facility for light water reactor fuel in the United States. Moreover, the NRC has licensed Framatome fuel in the past, so the company can use its existing expertise to support NuScale fuel fabrication needs.

- Specific policy measures in the United States. There are areas in the United States that have relatively unique advantages for deployment of a first-of-a-kind reactor.

For example, the presence of individual state policies, such as Idaho's state tax limitation,[103] and Washington State's clean energy standard, may provide unique incentives for deployment.[104] The federal production tax credit and the federal loan guarantee program from the Energy Policy Act of 2005 provide additional support that can be layered on top of those incentives. Other countries may lack comparable policy instruments and incentives.

- Building reactors at or near DOE facilities. In recent years, there has been greater discussion of siting an advanced reactor demonstration project at or near one of the DOE national laboratories, and to sell power from the reactor to the nearby DOE facility. The DOE national laboratory complex is an unmatched resource around the world. The labs provide a pool of world-class talent and nuclear facilities that can be utilized, and they are surrounded by local communities that are more familiar with nuclear issues. The US government has also issued site use permits in two cases to advanced reactor developers—NuScale Power and Oklo—to potentially build reactors on federal land, in both cases at Idaho National Laboratory. In addition, DOE and Terrestrial Energy USA, an affiliate of the Canadian company Terrestrial Energy, signed a memorandum of understanding regarding the terms of the possible siting, construction, and operating of their molten salt reactor design at a site at the Idaho National Laboratory.[105]

- The cost of advanced reactor development and demonstration may be too high for other countries. It is also possible that an individual country may conclude that even if it wanted to develop a reactor design of its own, it simply cannot afford to produce a final advanced reactor design by itself. As part of previous reactor demonstration programs, DOE has entered into public-private partnerships (e.g., the SMR LTS agreement with NuScale, where the federal share was $226 million) involving federal investments greater than what many other governments are likely able to put forward. For that reason, countries may see being a minority investor in a US advanced reactor design as the only viable option, given the scale of advanced reactor development and demonstration costs discussed in chapter 3.

To foster additional partnerships and collaborations, the DOE Office of Nuclear Energy could consider establishing a forum for US government officials to meet with government officials from US allies and discuss policies and plans under Mission Innovation to make progress on demonstrating advanced reactors. The forum could include private entities from the same group of countries who are interested in, or are already pursuing, advanced reactor demonstrations.[106] A starting list of countries for the United States to involve in the forum might be those that are part of Mission Innovation, and which also have mutual defense agreements with the United States: Australia, Brazil, Canada, Chile, Denmark, France, Germany, Italy, Japan, Netherlands, Norway, the ROK, and the UK.

In theory, the Generation IV Forum could be adapted for this purpose, but the presence of Russia and China is problematic for the reasons discussed above. In addition, not all countries in the Generation IV Forum are Mission Innovation members (e.g., Argentina, South Africa, Switzerland). The Generation IV Forum also appears to have some structural drawbacks for facilitating the demonstration of advanced reactor designs in the spirit of Mission Innovation and the Breakthrough Energy Coalition, including its focus on reactors based exclusively on a list of coolants. If there is not a suitable path to adapt existing fora, then the Office of Nuclear Energy could explore convening senior government officials and relevant private entities from the above-listed countries in a separate forum.

Such a forum could facilitate more partnerships and cross-investments among private entities, as well as targeted support from national governments to achieve multiple advanced reactor demonstrations. Mission Innovation and Breakthrough Energy Coalition are a two-pronged approach that involves assembling investment and resources by both public and private entities. Therefore, such a meeting could serve as a discussion forum between private entities, as well as a dialogue space for public officials. The public-sector component of the forum could, for example, allow officials to discuss what their respective governments are doing to facilitate advanced reactor demonstration, share lessons learned and best practices for government demonstration mechanisms, and foster greater awareness between the allied governments about their respective efforts. This could nurture working relationships between government officials and educate the private entities from each country on what their governments' respective advanced reactor demonstration efforts and national climate and energy policies are.

There are inevitably tensions and challenges associated with cooperation on proprietary, nonpublic reactor designs with billions (or tens of billions) of dollars of business at stake. Other governments' incentives for providing public investment are likely much the same as the US government's: domestic jobs, manufacturing content, intellectual property and export control, among others. For example, both the United States and the UK have been interested in small modular reactors for largely the same reasons.[107] Indeed, the UK recently announced a matching investment with a UK company, Rolls Royce, to develop a small modular reactor that could eventually become a competitor to US companies, such as NuScale.[108] While these are natural tensions between public and private entities that, to varying degrees, compete with one another, the examples cited above show instances where public and private entities have found ways to establish mutually beneficial collaborations.

FINDINGS AND RECOMMENDATIONS

Finding 1

Deepened cooperation with US allies would likely increase the chances of successful advanced reactor demonstration, as development costs and the construction of first-of-a-kind demonstration projects can each reach over a billion dollars. Greater collaboration between the United States and its allies would help accelerate the development and commercial availability of new advanced reactors, an important step toward addressing climate change. The timelines for advanced reactor development can be long and the development costs discouraging. Spreading costs among US allies and using a shared group of existing facilities and expertise would expedite successful advanced reactor demonstrations.

For example, partnerships and investment from French, British, and ROK entities have helped NuScale Power assemble the investment needed to reach a final design, and to use existing infrastructure and knowledge to avoid additional development costs. Kairos Power is another US company that is working with a close ally—Canada—to reduce its development costs. Similarly, other advanced reactor companies could benefit from expertise, facilities, and financial resources provided through partnerships with entities in allied nations.

Recommendation 1

The US Congress should amend the FOCD provisions in Sections 103d and 104d[109] of the AEA, as this restriction has created unnecessary problems for cooperation with US allies many times. The NRC has explained to Congress why the FOCD restriction is problematic and previously proposed a legislative amendment to fix it, which should serve as a starting point for congressional consideration. In general, the United States should look for more opportunities to strengthen cooperation with its allies. Chapter 2 discussed the opportunity to modernize the 1954 FOCD provision. Almost twenty years ago, the Chairman of the NRC, Richard Meserve, testified to Congress that the FOCD restriction was "increasingly problematic" and proposed a legislative amendment to remedy the problem. No subsequent action was taken by Congress, and the FOCD provision has continued to hinder nuclear energy cooperation between the United States and its allies.

The NRC's "Fresh Assessment" of FOCD matters in 2014 has unfortunately failed to bring about consensus on the topic, much less a solution. Indeed, the split decision at the commissioner level (into three groups) has further muddied the regulatory waters and increased the chances of future FOCD-related litigation. The NRC's prior legislative proposals to eliminate the AEA's FOCD provision offer a constructive starting point for congressional consideration of the issue. The NRC, in short, already has the authority to effectively address safety and security issues via the inimicality determination that the AEA requires it to make for every power reactor license.

The FOCD restriction effectively decreases the value of nuclear assets compared with other energy projects, because other energy generation technologies (e.g., solar, wind, natural gas, coal) are not subject to the same statutory limitations on foreign investment. Foreign investors have invested billions in the US shale industry, including outright acquisitions.[110]

The FOCD provision is inherently problematic because it effectively treats investments from US allies like Canada, France, and the UK in an equal manner to investments from potentially problematic countries like China and Russia. This is not consistent with how the US government approaches nuclear cooperation with nations in other contexts, where US allies are differentiated from nonallies. If a Canadian or UK nuclear reactor company wishes to build its own nuclear reactor design in the United States and is willing to fund more than half of the costs, it is hard to see why US law should formulaically block them from doing so without consideration for how to facilitate such projects (e.g., through the use of mitigation measures).

Recommendation 2

The DOE should reassess its nuclear energy international programs, given they predate the Paris Agreement, new geopolitical developments, and recent state and congressional activity. DOE should explore aligning these programs to support advanced reactor demonstration efforts with public and private entities from US allies. Since the international nuclear energy fora that DOE supports were first initiated, several important developments have occurred:

- The Paris Agreement was reached in 2015, and the Mission Innovation and Breakthrough Energy Coalition initiatives were announced.
- In support of climate efforts, individual states (e.g., California and Washington) have passed laws requiring zero-carbon electricity supplies by roughly midcentury.
- The United States announced a major policy shift against advanced reactor cooperation with China.
- An interest has arisen in Congress to require DOE to demonstrate several new, innovative, safer, and less costly reactors.

DOE's current international nuclear energy programs are not focused on facilitating public and private investment in advanced reactor demonstration between the United States and its allies in the spirit of Mission Innovation and the Breakthrough Energy Coalition. Doing so could help facilitate more cooperation between the United States and other like-minded countries, potentially reducing development costs and accelerating the availability of advanced reactor options.

With the US nuclear industry struggling—as well as those in key allied nations—greater cooperation appears more necessary than ever, especially given the time urgency and challenge posed by climate change. In addition to the actions recommended in this report, the United States should look for other opportunities to deepen nuclear energy cooperation with its allies.

NOTES

1. Matt Bowen, "Why the United States Should Remain Engaged on Nuclear Power: Climate Change and Air Pollution," Center on Global Energy Policy, June 2020, https://energypolicy.columbia.edu/research/commentary/why-united-states-should-remain-engaged-nuclear-power-climate-change-and-air-pollution.
2. For example, the members of the North Atlantic Treaty Organization (NATO) have committed to consider an attack against one or more of the NATO parties to be an attack against all of them. For other defense agreements, see https://2009-2017.state.gov/s/l/treaty/collectivedefense//index.htm.
3. See chapter 2 and appendix E of the Nuclear Innovation Alliance report "Part 810 Reform" for a discussion of some of the country-specific elements to nuclear energy cooperation between the United States and other countries in the 1950s and 1960s.
4. See, for example, the NRC's 10 CFR Part 110 regulations. Section 110.26 contains a list of "approved" countries to which US companies are generally authorized to export certain reactor components to—that is, they do not need to obtain a specific license from the NRC in order to do so. Unsurprisingly, US allies such as Japan, the ROK, France, Canada, and the UK are on this list, but China and Russia are not. Similarly, DOE's 10 CFR Part 810 regulations contain a list of countries to which US companies are generally authorized to export power reactor technology. The same US allies are included in this list, which also excludes China and Russia.
5. As chapter 2 discusses, for example, the NRC produced a draft idea for how to screen foreign entities in SECY-16-0056 that would incorporate mutual defense agreements as part of the criteria.
6. Jane Nakano, "The Changing Geopolitics of Nuclear Energy: A Look at the United States, Russia, and China," Center for Strategic and International Studies, March 2020.
7. Steve Krahn and Andrew Sowder, "Historical Assessment of Government-Industry Roles in the Research, Development, Demonstration and Deployment of Nuclear Power," *Transactions of the American Nuclear Society* 117 (October 29–November 2, 2017).
8. Robert Perry, with A. J. Alexander, W. Allen, P. deLeon, A. Gandara, W. E. Mooz, E. Rolph, S. Siegel, and K. A. Solomon, "Development and Commercialization of the Light Water Reactor, 1946–1976," RAND R-2180-NSF, June 1977.
9. See the UK regulator's website for past and current assessments of reactor designs: http://www.onr.org.uk/new-reactors/assessment.htm.
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11. Annette Cary, "Tri-City Employer of 550 Changes Its Name—Again," *Tri-City Herald*, January 4, 2018.

12. Tom Hals and Jessica Di Napoli, "Brookfield Business Partners to Buy Westinghouse for $4.6 billion," Reuters, January 4, 2018, https://www.reuters.com/article/us-westinghouse-m-a-brookfieldbusinesspa/brookfield-business-partners-to-buy-westinghouse-for-4-6-billion-idUSKBN1ET1MQ.

13. For example, as a recent letter to the Moon Administration argues: http://environmentalprogress.org/south-korea-letter.

14. The strategic significance of this development is discussed in the 2020 CGEP Commentary, "Why the United States Should Remain Engaged on Nuclear Power."

15. John J. Hamre, "Sustaining American Leadership in the Nuclear Industry," Hoover Institution Press, Stanford University, 2015. Page 4 argues: "The chief architects of the nonproliferation system—America and Europe—will become increasingly marginal players in the commercial nuclear power industry. In twenty-five years, America may drop from operating 25 percent of the world's reactors to less than 5 percent. Yet our national security interests in sustaining the nonproliferation regime will grow stronger."

16. As discussed later in the paper, the Trump Administration has announced its intention to withdraw from the Paris Agreement, which could occur as early as November 4, 2020.

17. An extra "any" is the way the law is written, so the statute reads "any any."

18. After World War II, the JCAE was created to oversee all aspects of atomic energy. The eighteen-member congressional committee has at times been described as one of the most powerful congressional committees in the history of the United States. According to the Congressional Research Service report, "9/11 Commission Recommendations: Joint Committee on Atomic Energy—A Model for Congressional Oversight?" from August 20, 2004: "During its 30-year life, the JCAE was universally regarded as one of the most effective committees in congressional history. On behalf of the two chambers of Congress that it served, the JCAE exercised strong oversight, coordinated and shaped policy in its field, and played an enormous role in the development of atomic power and the nuclear arsenal of the United States."

19. See page 1 of enclosure 1 of Mark A. Satorius, Nuclear Regulatory Commission Staff, "Fresh Assessment of Foreign Ownership, Control, or Domination of Utilization Facilities," SECY-14-0089, August 20, 2014. (This document will hereafter be referred to as "SECY-14-0089.")

20. See pages 96–98 of Sachin Desai and Kathleen Schroeder, "US Nuclear Foreign Ownership Policy Ready for a Refreshed Interpretation," *Energy Law Journal* 37, no. 1 (2016): 85–134. (This publication will hereafter be referred to as "Desai and Schroeder, 2016.")

21. Desai and Schroeder, 2016.

22. This report focuses on new commercial power reactors, which would be licensed under

Section 103. However, Section 104 of the AEA, 42 U.S.C. 2134, also contains the same FOCD provision, and applies to limited medical and research reactors. The FOCD provisions related to new facilities licensed under Section 104 are also problematic for essentially the same reasons and should thus be remedied as well.

23. This report is not suggesting that nuclear energy be treated the same in all respects as other energy technologies. There are, of course, important differences between nuclear power plants and other energy sources, and even if the FOCD restriction were lifted for commercial reactors, nuclear plants would still be heavily regulated.

24. For example, a 2014 Brookings post discusses German investment in a solar facility in Oregon, Danish investment in a wind turbine facility in Colorado, South Korean investment in a battery facility in Michigan, and French investment in a (non–power reactor) nuclear energy facility in North Carolina. https://www.brookings.edu/blog/the-avenue/2014/12/19/galvanize-foreign-direct-investment-in-u-s-clean-energy/.

25. Fortune Global 500, "Royal Dutch Shell," 2017, https://fortune.com/global500/2017/royal-dutch-shell/.

26. See page 1 of enclosure 2 of SECY-14-0089.

27. See pages 3–21 of enclosure 2 of SECY-14-0089 for discussion of the 17 cases.

28. See, e.g., John E. Matthews, Goud P. Maragani, and Esther K. Park, "Foreign Investment in US Nuclear Reactors: Mitigation Measures to Overcome Statutory Roadblock," August 15, 2009, https://www.morganlewis.com/-/media/files/publication/outside-publication/article/usnuclearreactors_15aug09.ashx.

29. See pages 8–10 of enclosure 2 of SECY-14-0089 for a discussion of the Cintichem case.

30. The provision was passed as part of Section 109 of the NRC Authorization Act for Fiscal Years 1984 and 1985, Public Law No. 98-553, 98 Stat. 2825.

31. See page 40 of SECY-14-0089 for a discussion of the South Texas Project NAP.

32. In the transcript of the ASLB hearing on January 8, 2014, Mr. Steven P. Frantz, on behalf of NINA, states: "Mr. McBurnett testified that there's only a need for around $11 million to complete licensing activities. A very small amount." This is on a project on which CPS Energy ultimately wrote off $391 million, NRG wrote off $331 million, and Toshiba $150 million. From https://www.expressnews.com/business/local/article/CPS-Energy-writes-off-391-4-million-from-South-6852804.php and https://www.mysanantonio.com/news/energy/article/NRG-will-no-longer-invest-in-STP-expansion-1343841.php.

33. The interveners were Sustainable Energy and Economic Development Coalition, the South Texas Association for Responsible Energy, and Public Citizen.

34. The transcript of the hearings on January 6, 7, and 8, 2014, are posted on the NRC ADAMS website. The accession numbers are ML14009A487, ML14010A439, and ML14016A469.

35. The reactor project was applying for a US Department of Energy loan guarantee to help finance over half of the project costs. Curiously, when under questioning by the ASLB chair, the NRC staff seemed to hedge on whether US federal agencies might be under foreign control. From the transcript:

    Chair Gibson: Would you agree that the Department of Energy and other agencies of the US Government are not subject to foreign control?
    Ms. Simmons: I would agree that they're not subject to foreign control, to my knowledge.

36. Nuclear Innovation North America LLC (South Texas Project, Units 3 and 4), LBP-14-3, 79 NRC 267 (2014), review denied, CLI-15-7, 81 NRC 481 (2015).

37. World Nuclear News, "Ownership Issues Block Unistar Licence," August 31, 2012, http://www.world-nuclear-news.org/Articles/Ownership-issues-block-Unistar-licence.

38. Nuclear Information and Resource Services, Beyond Nuclear, Public Citizen Energy Program, and Maryland Public Interest Research Group.

39. Petition to Intervene in Docket No.52-016, Calvert Cliffs-3 Nuclear Power Plant Combined Construction and License Application, November 19, 2008.

40. *Calvert Cliffs 3 Nuclear Project, LLC, and UniStar Nuclear Operating Services, LLC* (Calvert Cliffs Nuclear Power Plant, Unit 3), LBP-12-19, 76 NRC 184 (2012).

41. CLI-13-4, 77 NRC 101 (2013). At the time, UniStar had indicated that it would look for a US partner to hold part of EDF's 100 percent ownership share. Accordingly, the commission refrained from examining the merits of the ASLB's ruling. UniStar later withdrew the entire application and abandoned the project.

42. The specific quote from Commissioner Svinicki: "If concerns associated with a 99.9 percent indirect foreign ownership can be 'mitigated away' through a NAP, then similar concerns associated with 100 percent indirect ownership legitimately can, too."

43. Desai and Schroeder, 2016.

44. NRC Docket Number NRC-2016-0088 and Docket Number 2016-12545 and 2016-12546.

45. Andy Shain, "Potential Buyer Eyeing Abandoned $9 Billion SC Nuclear Project, Legislator Says," May 3, 2019, https://www.postandcourier.com/politics/potential-buyer-eyeing-abandoned-billion-sc-nuclear-project-legislator-says/article_5939affa-6db5-11e9-beb3-d7ab843a5b3d.html.

46. Noah Barkin, "Five Eyes Intelligence Alliance Builds Coalition to Counter China," Reuters, October 12, 2018.

47. Nuclear Threat Initiative, "U.S.-U.K. Mutual Defense Agreement Extended," November 26, 2004, https://www.nti.org/gsn/article/us-uk-mutual-defense-agreement-extended/.

48. Public Briefing Session on Foreign Ownership, Control and Domination before the United

States Nuclear Regulatory Commission, Washington, DC, January 29, 2015, https://www.nrc.gov/docs/ML1503/ML15030A162.pdf.

49. Public Briefing Session.

50. Letter from Chairman Shirley Ann Jackson to the Honorable Albert Gore Jr., May 13, 1999 (ADAMS Accession No. ML13312A018) (transmitting the NRC's legislative proposals to the Senate).

51. This report focuses on Section 103d, which applies to power reactors, instead of 104d, which applies to research and medical reactors.

52. H.R. 2531, 106th Cong. § 205 (July 15, 1999).

53. H.R. 2531 *Hearings before the House Subcomm. on Energy and Power of the Comm. on Commerce*, 106th Cong. 1 (July 21, 1999). *Nuclear Regulatory Commission: Regulatory Reforms, Hearing before the Senate Subcomm. on Clean Air, Wetlands, Private Property and Nuclear Safety*, 106th Cong. 35 (Mar. 9, 2000). *Nuclear Regulatory Commission: Fiscal Year 2002 Programs, Hearing before the Senate Subcomm. on Clean Air, Wetlands, Private Property, and Nuclear Safety* 61, 150–51 (May 8, 2001).

54. SECY-14-0089, August 20, 2014.

55. 146 Cong. Rec. S152 (daily ed. Jan. 31, 2000) (Statement of Sen. Domenici). The bill in question was S.2016.

56. *Nuclear Regulatory Commission: Regulatory Reforms, Hearing before the S. Subcomm. on Clean Air, Wetlands, Private Property and Nuclear Safety*, (March 9, 2000) (Statement of the Hon. Richard A. Meserve, Chairman, NRC)

57. Letter from Chairman Richard A. Meserve to the Hon. Richard B. Cheney, June 22, 2001 (ADAMS Accession No. ML011770414).

58. *Nuclear Regulatory Commission: Fiscal Year 2002 Programs, Hearing before the S. Subcomm. on Clean Air, Wetlands, Private Property, and Nuclear Safety* 61, 150–51 (May 8, 2001) (Statement of Hon. Richard A. Meserve, Chairman, NRC)

59. James A. Glasgow and Stephen L. Markus, "The NRC's Foreign Ownership Policy: Charting a New Course for the 21st Century," July 12, 2013.

60. The draft regulatory guidance is available at https://www.nrc.gov/docs/ML1613/ML16137A520.pdf.

61. The draft SRP is available at https://www.nrc.gov/docs/ML1604/ML16048A025.pdf.

62. Staff Requirements Memorandum, SRM-SECY-14-0089, May 4, 2015.

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Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Thailand, Turkey, and the United Kingdom. Available at: https://www.nrc.gov/docs/ML1602/ML16029A040.pdf.

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65. *National Industrial Security Program Operating Manual ("NISPOM") Section 2-300.* (DoD 5220.22-M, 2/28/2006). The full quote is: "Foreign investment can play an important role in maintaining the vitality of the U.S. industrial base. Therefore, it is the policy of the U.S. Government to allow foreign investment consistent with the national security interests of the United States. The following FOCI policy for U.S. companies subject to an FCL [facility security clearance] is intended to facilitate foreign investment by ensuring that foreign firms cannot undermine U.S. security and export controls to gain unauthorized access to critical technology, classified information, and special classes of classified information."

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