Written Testimony of Amy C. Roma

Founding Member, Nuclear Energy and National Security Coalition (NENSC), Atlantic Council; Partner, Hogan Lovells US LLP

Before the Senate Committee Energy and Natural Resources

Full Committee Hearing on The Latest Developments in the Nuclear Energy Sector with a Focus on Ways to Maintain and Expand the Use of Nuclear Energy in the United States and Abroad

Thursday, March 25, 2021, 10:00 a.m.

My name is Amy Roma and I am a founding member of the Nuclear Energy and National Security Coalition at the Atlantic Council and a nuclear regulatory lawyer at the law firm of Hogan Lovells. Thank you for the opportunity to testify before the Committee. This testimony represents my observations and in no way represents the views of the Atlantic Council, Hogan Lovells or its clients.

Commercial nuclear power has always served as an important tool to achieve U.S. national security objectives and U.S. economic interests. That holds just as true today as it did at the advent of the civilian nuclear power industry at the end of World War II. But nuclear power also affords additional key benefits, which have emerged more recently, making this technology even more important. First, nuclear power does not emit greenhouse gases, including carbon, and therefore can serve as a crucial tool in the battle against climate change, for both carbon-free power generation and decarbonization of other sections such as industry and transportation. Second, nuclear power provides reliable power for generations. With the world electricity demand expected to double by 2050,[1] nuclear power has the ability to provide clean, affordable, and reliable power around the world, helping raise the global standard of living, including for the approximately 860 million people in the world with no access to electricity.[2]

I walk through these considerations below, first explaining the current state of affairs and how we got here, and then by walking through the opportunities to improve the U.S. position. There is a lot in here, that touches upon national security, global politics and policies, national politics and policies, economic opportunities and jobs creation, technological innovation—as it stands today and important areas where it will be going,and climate change. The facts are dense

[1] Energy Information Agency, *EIA projects nearly 50% increase in world energy usage by 2050, led by growth in Asia* (Sept. 24, 2019) (*available at* https://www.eia.gov/todayinenergy/detail.php?id=41433)
[2] TIME, *Bill Gates: Here's a Formula That Explains Where We Need to Invest in Climate Innovation* (Jan. 22, 2021) (*available at* https://time.com/5930098/bill-gates-climate-change/).

and the footnotes plenty, but there is an important story to tell and an important opportunity to seize.

I. A high stakes history lesson

Understanding the importance of commercial nuclear power begins with a history lesson that underscores the unique tool nuclear power can serve for the U.S. on the global stage.

Commercial nuclear power and the United States government share a long history that is intertwined with the global struggle for peace and security.[3] Soon after the end of the Second World War, the U.S. government understood that its monopoly on nuclear weapons and nuclear technology would be short lived. In particular, the Soviet Union was catching up with the United States and could share the information with other countries to benefit its own geopolitical aims and undermine U.S. influence, safety, and nonproliferation policies.[4]

Facing the recognition that nuclear power would eventually become a global technology, in the 1950s President Eisenhower and his administration saw the value that sharing the peaceful use of nuclear power could bring not just for the world, but for its own security. President Eisenhower presented a bold proposal to the United Nations: The U.S. would share its nuclear energy technology with other nations if the receiving nation committed to not use the technology to develop nuclear weapons.[5] This program, known as "Atoms for Peace," furthered three important economic and national security objectives: (1) it prevented the spread of nuclear weapons because it would lead and thus have oversight over global nuclear development; (2) it made the U.S. the leader in nuclear power, ensuring that the U.S. maintained dominance in nuclear safety, security, nuclear technology development, and nuclear trade; and (3) it ensured the U.S. benefitted from the geopolitical relationship that goes with such significant assistance with a foreign country's power supply.[6]

---

[3] Michael Wallace, Amy Roma, and Sachin Desai, *Back from the Brink: A Threatened Nuclear Energy Industry Compromises National Security*, Center for Strategic and International Studies (Jul. 2018) (*available at* https://www.csis.org/analysis/back-brink-threatened-nuclear-energy-industry-compromises-national-security). Much of the content of this section of my remarks repeats and reemphasizes the points made in this paper.

[4] Peter Lavoy, *Arms Control Today, The Enduring Effects of Atoms for Peace*, Arms Control Association (Dec.1, 2003) (*available at* https://www.armscontrol.org/act/2003_12/Lavoy) ("U.S. officials feared that the Kremlin would score a huge propaganda victory, especially in the developing world, if the United States did not alter its own nuclear export policy.")

[5] Address of Dwight D. Eisenhower, President of the United States of America, to the 470th Plenary Meeting of the United Nations General Assembly (Dec. 8, 1953) (*available at* https://www.iaea.org/about/history/atoms-for-peace-speech).

[6] It is worth reflecting that there are only nine counties today with nuclear weapons, despite President John F. Kennedy's prediction that there would be as many as 25 nuclear-armed states by the 1970's—this is in no small part due to these strong nonproliferation bulwarks put in place by the United States early in the development of nuclear power and the strong non-proliferation standards the U.S. continues to deploy today. Press Conference, President John F. Kennedy, President's News Conference (Mar. 21, 1963) (*available a*t https://perma.cc/B7LW-7WYR); Nuclear Weapons Programs Worldwide: An Historical Overview, INST. FOR SCI. & INT'LSECURITY (*available at* https://perma.cc/3XQV-P7LY).

President Eisenhower's historic move has paid dividends for decades. With the United States at the forefront, the Atoms for Peace policy gave rise to many of the most important safety and nonproliferation standards of today's nuclear world.

Remarkably, many of the same arguments used to support the U.S. government's decision to bring nuclear power to the world in the 1950s are still just as relevant today—that is, the United States should lead in nuclear trade because if we do not, another country will, which undermines U.S. influence and economic interests, as well as U.S. safety and nonproliferation standards. However, under today's current climate, Russia and China—and not the United States—dominate the global market. They have identified building nuclear power plants and nuclear trade as national priorities, and promote these priorities from the highest levels of government, backed by state financing and state-owned enterprises.

Their focus has paid off. Russia now dominates nuclear power plant construction around the world, using it as a tool to exert foreign influence and reap significant economic gains. Nuclear energy is also a component of China's "Belt and Road" initiative, with China expected to exceed the U.S. as the largest domestic producer of nuclear power by 2030,[7] and also emerge as a close competitor to Russia for international new nuclear projects.[8] The struggling U.S. nuclear power industry—competing against foreign governments for new projects abroad—has quickly been sidelined on the foreign stage. *See* Appendix A for a global breakdown of Russian and Chinese nuclear exports.

While we have ceded the mantle currently, the United States has a chance to regain it when it comes to the next generation of advanced reactors, where we hold a significant innovation edge. In particular, the U.S. leads the world in the development of advanced fission reactors, as well as the nascent fusion industry.[9] U.S. innovation, when properly supported, can stand up to state backed competitors. We saw this in the aerospace market. In 2013, Russia controlled about half of the launch industry.[10] Due in large part to the success of SpaceX, shepherded by NASA's Commercial Orbital Transportation Services (COTS) program, Russia is now estimated to capture only 10% of the market.

---

[7] Nikkei Asia, *China poised to overtake US in nuclear power by 2030* (Aug. 31, 2020) *(available at* https://asia.nikkei.com/Business/Energy/China-poised-to-overtake-US-in-nuclear-power-by-2030#:~:text=China%27s%20total%20nuclear%20power%20generation,Nuclear%20Association%2C%20an%20industry%20group.

[8] Reuters, *China could build 30 'Belt and Road' nuclear reactors by 2030: official* (Jun. 20, 2019) (*available at* https://www.reuters.com/article/us-china-nuclearpower/china-could-build-30-belt-and-road-nuclear-reactors-by-2030-official-idUSKCN1TL0HZ).

[9] *See* Fusion Industry Association website for an overview of fusion companies in the United States (*available at* https://www.fusionindustryassociation.org/). The U.S. Nuclear Regulatory Commission is currently evaluating the regulatory framework for fusion.

[10] Ars Technica, *Russia appears to have surrendered to SpaceX in the global launch market* (Apr. 18, 2018) (*available at* https://arstechnica.com/science/2018/04/russia-appears-to-have-surrendered-to-spacex-in-the-global-launch-market/)

Likewise, if the United States leads in implementing this new technology wave with advanced reactors, we can regain leadership in the global nuclear industry, resulting in significant gains to U.S. interests.

II. The current state of the domestic nuclear industry

Nuclear boasts attractive features that routinely garner bipartisan support. It is on President Biden's radar as well as on the legislative agenda for both parties. The United States is currently the world's largest producer of nuclear power, accounting for more than 30% of worldwide nuclear generation. Nuclear energy provides approximately 20% of U.S. power generation and around 55% of the country's carbon-free power generation, with a fleet of about 95 reactors, operated by 30 different power companies across 30 different states.[11]

The nuclear industry supports nearly half a million jobs in the United States and contributes about $60 billion to the U.S. GDP annually.[12] Each nuclear power plant can employ up to 700 workers with salaries that are 30% higher than the local average, and they contribute billions of dollars annually to local economies through federal and state tax revenues.[13] In addition to providing large amount of carbon-free power, it also operates incredibly well, providing reliable power with an average capacity factor[14] of over 90% making it one of the most reliable power generation sources.[15] Unlike many other forms of power generation, nuclear plants are also able to operate up to 60 and 80+ years, if they are licensed to do so, making nuclear power a reliable long-term investment. It is not surprising that nuclear power has been called "the safest, least polluting, least warming, and most reliable energy source humanity has yet devised."[16]

Despite these benefits, the current U.S. nuclear industry is facing a perilous decline. Almost all current U.S. nuclear generating capacity comes from reactors built between 1967 and 1990. As recently as 2013, the U.S. had 104 operating domestic nuclear power reactors, with dozens of new reactors planned in the early 2000s. But due in part to the long-term decline in natural gas prices beginning around 2008, the tide turned for the industry. Essentially all the new reactor projects were cancelled. Today the number of reactors has decreased to around 95 today with more scheduled for early decommissioning, and about 1/3 facing economic hardships.[17] While two new plants are under construction, no other large scale units are planned after this time. And with

[11] World Nuclear Association, *Nuclear Power in the USA* (updated January 2021) (*available at* https://www.world-nuclear.org/information-library/country-profiles/countries-t-z/usa-nuclear-power.aspx).

[12] U.S. Department of Energy, Office of Nuclear Energy, *Advantages and Challenges of Nuclear Energy* (Jan. 26, 2021) (*available at* https://www.energy.gov/ne/articles/advantages-and-challenges-nuclear-energy#:~:text=Creates%20Jobs,higher%20than%20the%20local%20average).

[13] *Id.*

[14] Capacity factor is the ratio between what a generation unit is capable of generating versus the unit's actual generation output over a period of time. Among other things, the higher the capacity factor, the more predictable the output of the plant.

[15] Energy Information Agency, Electric Power Monthly, *Table 6.07.B. Capacity Factors for Utility Scale Generators Primarily Using Non-Fossil Fuels* (through Dec. 2020) (*available at* https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_6_07_b) (For comparison, wind has about a 35% capacity factor, and solar PV has about a 25% capacity factor).

[16] Richard Rhodes, Energy: A Human History, Simon & Schuster; 1st edition (2018) at 336-37.

[17] Energy Information Agency, Frequently Asked Questions (FAQS) (*available at* https://www.eia.gov/tools/faqs/faq.php?id=207&t=3).

roughly half of the nuclear fleet operating in "merchant" markets priced for the short term, the low price of natural gas is making nuclear plants temporarily uncompetitive. At the same time, however, certain critical benefits of nuclear power plants—e.g., reliability, grid stability, low-carbon energy source, national security asset—go largely uncompensated.

The loss of commercial nuclear power plants in the United States has also created and will continue to exacerbate a decline in the supporting infrastructure—especially in the front end fuel cycle supply chain (e.g., uranium mining, milling, conversion, enrichment, and fuel fabrication), human supply chain, and the military to civilian workforce pipeline—further jeopardizing not only our domestic ability to support our domestic fleet, but also our national security as that same infrastructure indirectly supports our nuclear maritime and other military capabilities. For example, despite having large uranium reserves, the United States has nuclear fuel production capacity that is not sufficient to meet our domestic needs and 95% of uranium used in U.S. commercial reactors is imported.[18] Until recently, the U.S.' only uranium conversion facility was shuttered, and while we do have an operating uranium enrichment facility in the United States, we do not currently have domestic enrichment capabilities to support the high-assay low enriched uranium (HALEU) fuel needs of our emerging advanced reactor companies.[19]

Despite these challenges, U.S. reliance on nuclear power has actually *grown*, with U.S. nuclear generation capacity doubling because of increased operational efficiencies and power plant utilization, and power uprates.[20] A number of states have moved to keep economically troubled nuclear power plants open to preserve their low carbon attributes, using a "Social Cost of Carbon" metric to support the cost-benefit analyses of the programs.[21] But these state actions are all stop gap measures until a more permanent solution emerges. Unless new initiatives are shown, more nuclear power plants are expected to prematurely shutdown leading to a significant degradation of the existing commercial fleet.

---

[18] World Nuclear Association, *U.S. Nuclear Fuel Cycle* (updated February 2021) (*available at* https://www.world-nuclear.org/information-library/country-profiles/countries-t-z/usa-nuclear-fuel-cycle.aspx). To make clear, the United States has extensive domestic uranium resources, ranking ninth in the world for known uranium resources, with about 4 percent of the world total. At peak production, around 1980, there were over 250 uranium mines in operation, but there has been a steady decline in production since that time.

[19] *Id. See also* Department of Energy's Office of Nuclear Energy, *What is High-Assay Low-Enriched Uranium (HALEU)?* (Apr. 7, 2020) (*available at* https://www.energy.gov/ne/articles/what-high-assay-low-enriched-uranium-haleu). Most of the advanced reactor companies rely on HALEU, which is not commercially made in the United States. While the U.S. has some stockpiled, the stockpile is expected to run out of the next decade or so, which is also critical as the same stockpile is used to provide fuel for the U.S. naval propulsion program and power our nuclear navy. The U.S. Navy has approximately 100 nuclear reactors in its submarines and surface ships. *See* World Nuclear Association, Nuclear-Powered Ships (updated Feb. 2021), *available at* https://www.world-nuclear.org/information-library/non-power-nuclear-applications/transport/nuclear-powered-ships.aspx.

[20] Energy Information Agency, *Nuclear explained: U.S. nuclear industry* (last updated Apr. 15, 2020) (*available at* https://www.eia.gov/energyexplained/nuclear/us-nuclear-industry.php).

[21] For a summary of these program, please see HL New Nuclear Blog, *Biden Administration Reinvigorates the Social Cost of Greenhouse Gases*, by Amy Roma and Sachin Desai (Mar. 5, 2021) (*available at* https://www.hlnewnuclear.com/2021/03/biden-administration-reinvigorates-the-social-cost-of-greenhouse-gases/).

III. The current state of the global nuclear marketplace and the huge opportunity it affords

The nuclear community is expanding across all corners of the globe. There are currently around 440 reactors in operation around the world, with about 50 reactors under construction in 16 countries.[22] There are also a number of advanced reactor technologies under development—about 130 in total—using cutting-edge technologies and capabilities (*see* Appendix B).[23] And this is just the beginning as nuclear power is increasingly seen as a critical tool in combatting climate change and electrifying the underserved populations of the world with clean, reliable, and affordable energy.

According to projections from Third Way and the Energy for Growth Hub, the market for nuclear could triple by 2050 and generate $400 billion of electricity annually.[24] The Department of Commerce has identified that over the next ten years, the international market for nuclear equipment and services will yield about $740 billion, and every $1 billion of exports by U.S. companies could support anywhere from 5,000 to 10,000 jobs domestically.[25] If carbon mitigation measures are deployed, the 30-year cumulative market domestic opportunity for nuclear power could reach up to $2 trillion, within a global market valued at around $8.6 trillion.[26] But even without any carbon mitigation measures, the current market for new nuclear power is in the hundreds of billions of dollars. There are very big numbers that present a very big opportunity for the United States.

With prospects such as these on the horizon, if the U.S. expects to become competitive, it must align its policies and programs with that goal.[27] This is what the competition is doing. While globally, nuclear power is taking off, the U.S. has been struggling to gain a foothold in the foreign market competing against the aggressive tactics of Russia and China. These countries have invested heavily into building power plants across the world, starting with traditional large light water reactor technology offerings. Low-cost "turnkey" projects offered by the Russians and Chinese—which include state-supported financing packages, and "build, own, operate" models that handles the entire project and fuel cycle from start to finish—shuts out the United States. Nuclear development in these countries is government-backed, including financial, political and regulatory support, making it almost impossible for the U.S. to compete globally. *See* Appendix A.

---

[22] World Nuclear, *Plans for New Reactors Worldwide* (Mar. 2021) (*available at* https://www.world-nuclear.org/information-library/current-and-future-generation/plans-for-new-reactors-worldwide.aspx).
[23] Third Way, *2020 Advanced Nuclear Map: Progress Amidst a Tumultuous Year* (Dec. 21, 2020) (*available at* https://www.thirdway.org/graphic/2020-advanced-nuclear-map-progress-amidst-a-tumultuous-year).
[24] Third Way, *Mapping the Global Market for Advanced Nuclear* (Sept. 22, 2020) (*available at* https://www.thirdway.org/memo/mapping-the-global-market-for-advanced-nuclear).
[25] Nuclear Energy Institute, *Nuclear Exports & Trade Overview* (*available at* https://www.nei.org/advocacy/compete-globally).
[26] *Global Nuclear Market Assessment Based on IPCC Global Warming of 1.5° C Report*, Prepared by UxC, LLC for the Nuclear Energy Institute (Jul. 2020), at 1 and 4 (*available at* https://www.nei.org/resources/reports-briefs/uxc-global-nuclear-market-assessment-report).
[27] Breakthrough Energy, *Advancing the Landscape of Clean Energy Innovation* (Feb. 2019) (*available at* https://www.breakthroughenergy.org/reports/advancing-the-landscape/).

Russia dominates the global nuclear new build marketplace, and has secured 60% of nuclear reactor sales around the world.[28] Russia has more than 50 reactors either under construction, planned, or proposed in 19 countries.[29] Russia has stated that its book of business for nuclear construction projects is well over $130 billion,[30] and it further estimates that every 1 ruble of nuclear export contributes 2 rubles to national GDP. Russia has also developed the first modern floating small modular reactor technology, and is paving the way for fast reactors with closed nuclear fuel cycles through its Proryv Project where fuel is recycled to reduce nuclear waste.

China is coming up close on its heels.[31] China has built almost half of all nuclear reactors constructed since 2000 and has designed numerous others outside its borders.[32] China further estimates that it could build as many of 30 overseas reactors by 2030 (which is just 20% of the anticipated "Belt and Road" market), earning up to $145.5 billion and employing up to 5 million Chinese workers.[33] China has 49 operable nuclear reactors domestically and 16 currently under construction.[34] Aligned with its goal of becoming a leader in nuclear, China is exploring advanced nuclear options as well as maintaining and developing its nuclear fleet. As noted above, China is building a molten salt reactor for potential application on aircraft carriers for naval population and flying drones.[35] China also recently closed its bidding process that solicited interest for a 152-meter, 33,069-ton nuclear-powered vessel.[36]

These government investments are not wasteful but strategic, because Russia and China realize the economic and geopolitical benefits of having their customers dependent on Russian and Chinese-managed energy resources, and keeps Russia and China on top of technical innovations that can advance their own interests.

Russian energy policy, in particular, expressly recognizes the export of energy technologies as a geostrategic tool to promote Russian national security. While China appears to generally view nuclear power exports as an important economic opportunity, its expansion into developing new

---

[28] Nuclear Energy Institute, *Russia and China Are Expanding Nuclear Energy Exports. Can the U.S. Keep Up?* (Oct. 6. 2020) (*available at* nei.org/news/2020/russia-china-expanding-nuclear-exports-us-keep-up). World Nuclear Association, *Plans for New Reactors Worldwide* (updated Jan. 2021) (*available at* https://www.world-nuclear.org/information-library/current-and-future-generation/plans-for-new-reactors-worldwide.aspx.)

[29] World Nuclear Association, *Nuclear Power in Russia* (updated Jan. 2021) (*available at* https://www.world-nuclear.org/information-library/country-profiles/countries-o-s/russia-nuclear-power.aspx.)

[30] *Id.*

[31] World Nuclear Association, *Plans for New Reactors Worldwide* (updated Jan. 2021) (*available at* https://www.world-nuclear.org/information-library/current-and-future-generation/plans-for-new-reactors-worldwide.aspx.)

[32] VOA News, *China on Track to Supplant US as Top Nuclear Energy Purveyor* (Jan. 14, 2020) (*available at* https://www.voanews.com/east-asia-pacific/voa-news-china/china-track-supplant-us-top-nuclear-energy-purveyor).

[33] *Xi Touts BRI Nuclear Energy*, Analysis: In the News, Center for Strategic and International Studies (Aug. 2, 2019), https://reconnectingasia.csis.org/analysis/entries/bri-goes-nuclear/.

[34] World Nuclear, *Nuclear Power in China* (Jan. 2021) (*available at* https://www.world-nuclear.org/information-library/country-profiles/countries-a-f/china-nuclear-power.aspx).

[35] Michael Wallace, Amy Roma, and Sachin Desai, *Back from the Brink: A Threatened Nuclear Energy Industry Compromises National Security*, Center for Strategic and International Studies (Jul. 2018) (available at https://www.csis.org/analysis/back-brink-threatened-nuclear-energy-industry-compromises-national-security).

[36] South China Morning Post, *Could China's 'experimental' ship be the world's biggest nuclear-powered icebreaker?* (*available at* https://www.scmp.com/news/china/military/article/3002455/china-build-30000-tonne-nuclear-powered-ship-described).

nuclear technologies also has defense implications. For example, China plans to build a number of floating nuclear reactors to provide power to the artificial islands that it is building in the South China Sea, a hotly contested area.[37] Also important to note, these reactors can support not only power for these islands but provide power for advanced weaponry.

As China and Russia succeed in the deployment of their nuclear energy technologies in emerging economies, they gain critical geopolitical influence in these countries by effectively controlling baseload power and the fuel cycle to run these nuclear units. This influence runs for the long-term, at least for the life of the project and plant which can stretch to 100 years, with long-term implications for the geopolitical balance of power and economic influence.

For example, Egypt and Russia recently finalized a $21 billion contract for the Russians to supply four reactors in Egypt.[38] A few months later, Egypt and Russia announced a preliminary agreement to allow Russian military jets to use its airspace and bases. The agreement will give Russia its deepest presence in Egypt since 1973.[39]

But there is opportunity still to turn things around as the world energy demand sky rockets and the decarbonization intensifies. Around 30 countries across the Middle East, Africa, Central and South America, Europe, and Southeast Asia are considering or beginning new nuclear power programs—each of which is an opportunity for the U.S. to regain a foothold in the global market.[40] In Europe, Hungary and Poland are planning to site new nuclear reactors to replace retired energy systems.[41] A United Kingdom government whitepaper sets forth the Prime Minister's plan to tackle climate change and includes both large and small scale nuclear.[42]

Simply put, the global market is huge and the opportunities to promote U.S. economic and national security interests are immense.

---

[37] *See China's Risky Plan for Floating Nuclear Power Plants In The South China Sea,* The Diplomat, by Viet Phuong Nguyen (May 10, 2018) (*available at* https://thediplomat.com/2018/05/chinas-risky-plan-for-floating-nuclear-power-plants-in-the-south-china-sea/).

[38] *See* Al-Masry Al-Youm, *Construction of First Nuclear Reactor at Dabaa Station to Start after Christmas Holidays*, Egypt Independent (Dec. 13, 2017) (*available at* http://www.egyptindependent.com/construction-first-nuclear-reactor-dabaa-station-start-christmas-holidays/). The article notes that of the $21 billion price tag for the four new reactors, Russia will fund 85 percent of the plant through a loan, and the rest will be financed by Egypt. The deal was finalized in September 2017.

[39] *See* David D. Kirkpatrick, *In Snub to U.S., Russia and Egypt Move toward Deal on Air Bases*, New York Times (Nov. 30, 2017) (*available at* https://www.nytimes.com/2017/11/30/world/middleeast/russia-egypt-air-bases.html.) ("The United States has provided Egypt more than $70 billion in aid in the four decades since, at a rate of more than $1.3 billion a year in recent years. The cost is often justified in part by the argument that it secures the use of Egypt's airspace and bases for the U.S. military.")

[40] World Nuclear, *Emerging Nuclear Energy Countries* (Mar. 2021), (*available at* https://www.world-nuclear.org/information-library/country-profiles/others/emerging-nuclear-energy-countries.aspx).

[41] World Nuclear News, *Hungary and Poland plan nuclear to replace coal* (Mar. 5. 2021) (*available at* https://www.world-nuclear-news.org/Articles/Hungary-and-Poland-plan-nuclear-to-replace-coal).

[42] HM Government, *Powering our Net Zero Future* (Dec. 2020) (*available at* https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/945899/201216_BEIS_EWP_Command_Paper_Accessible.pdf).

IV. Turning things around and leading with advanced reactors

In the near term, advanced reactors are the only planned new nuclear endeavors to add to the nuclear energy mix in the United States this decade, but they are also well poised to give the U.S. an opportunity to regain its global nuclear leadership.

There are about several dozen domestic ventures in next-generation nuclear technologies and new opportunities are being created every day—including two leaders in this field that are also providing testimony today (*see* Appendix B, for a global perspective of advanced nuclear development, showing significant activity in the United States).[43] These endeavors take many forms and have a variety of technical features. Indeed, there are also a number of fusion ventures looking to demonstrate and commercialize fusion power technologies.

Critically, however, nearly all contain enhanced safety systems, such as passive safety features and below grade construction. Moreover, nearly all of them offer modular designs that can start small and scale with customer needs. In addition, many advanced reactors have the ability to provide process heat, which can be used to decarbonize the industrial sector and support other innovative technologies, such as hydrogen production or water desalination, and even space propulsion/power and shipping, as discussed more below.[44]

Over the past decade advanced reactor designs have significantly matured, and many vendors are hoping to build their first plant this decade. On October 13, 2020, the U.S. Department of Energy awarded X-energy and TerraPower $80M each for their respective initiatives to build advanced nuclear reactors by 2027 under the Advanced Reactor Demonstration Program (ARDP). ARDP facilitates a 50-50 cost-sharing partnership with the nuclear industry to ensure that advanced nuclear technology is rapidly demonstrated. Several other advanced reactor company also received ARDP awards for their projects and are in discussions with the U.S. Nuclear Regulatory Commission (NRC) for licensing.[45] Another company, Oklo, has a combined construction permit and operating license application under review with the NRC, and NuScale recently received NRC approval of its design and is in discussions with Utah Associated Municipal

---

[43] Third Way, *Mapping the Global Market for Advanced Nuclear* (Sept. 22, 2020) (*available at* https://www.thirdway.org/memo/mapping-the-global-market-for-advanced-nuclear). Third Way has been tracking advanced reactor develops for several years now and their data shows an increased tick in participants each year. *See, e.g.,* Third Way, *Keeping Up with the Advanced Nuclear Industry* (Jan. 2018) (*available at* https://www.thirdway.org/graphic/keeping-up-with-the-advanced-nuclear-industry). This number shows a marked increase from the previous year, so the advanced reactor field is currently growing. *See also* Third Way, *The Advanced Nuclear Industry: 2016 Update* (Dec.12, 2016) (*available at* https://www.thirdway.org/infographic/the-advanced-nuclear-industry-2016-update).

[44] *See, e.g.,* World Nuclear Association, *Nuclear Process Heat for Industry* (updated September 2020) (*available at* https://www.world-nuclear.org/information-library/non-power-nuclear-applications/industry/nuclear-process-heat-for-industry.aspx) and *Nuclear Reactors and Radioisotopes for Space* (updated February 2021) (*available at* https://www.world-nuclear.org/information-library/non-power-nuclear-applications/transport/nuclear-reactors-for-space.aspx).

[45] *See* Department of Energy's Office of Nuclear Energy, *Energy Department's Advanced Reactor Demonstration Program Awards $20 million for Advanced Reactor Concepts* (Dec. 22, 2020) (*available at* https://www.energy.gov/ne/articles/energy-department-s-advanced-reactor-demonstration-program-awards-20-million-advanced).

Power Systems to site NuScale reactors at Idaho National Laboratory.[46] The Department of Defense is also working with U.S. companies to design a micro-reactor to deploy at forward operating bases to provide reliable power in war zones and eliminate fuel delivery-related deaths.[47]

If given a chance to thrive through private sector investment, regulatory streamlining, and political leadership on issues such as management of spent fuel, nuclear power could see an incredible resurgence in the United States, bringing significant benefits to its citizens, national security, and even prospects in space.

Listed below is just a brief selection of some of the benefits advanced reactors can provide the U.S. economy if adequately supported:

- **High-Paying Jobs:** Investment in nuclear power will result in skilled, highly compensated jobs in the nuclear industry, including the addition of professions such as reactor designers and service and maintenance professionals, as well as opportunities in fuel cycle facilities to mine, mill, and enrich uranium. These positions open the door for highly skilled domestic employees, many of whom come to the field from the Navy or after pursuing extensive university programs.[48] In fact, today nuclear power has the highest paying jobs in the entire electric power generation sector, with the average mid-wage workers earning somewhere between 22% and 25% more per hour than the next best paying electric power generation sector (e.g., coal and natural gas, respectively) and about 30% more than average local wages.[49]

- **Low-Carbon Power:** Advanced reactors are an important component to a diverse clean-energy fields. Advanced reactors can produce more energy than alternative renewable

---

[46] World Nuclear News, *NuScale and UAMPS agreements progress plans for SMR plan*t (Jan. 12, 2021) (*available at* https://world-nuclear-news.org/Articles/NuScale-and-UAMPS-agreements-progress-plans-for-SM).
[47] *See U.S. Military's mobile mini-nuclear: fewer fuel supply convoys mean fewer casualties*, Energy Post, by James Conca (May 17, 2019) (*available at* https://energypost.eu/u-s-militarys-mobile-mini-nuclear-fewer-fuel-supply-convoys-mean-fewer-casualties/)("Multiple studies identify that air and ground delivery of liquid fuel comes at a significant cost in terms of lives and dollars. Approximately 18,700 casualties, or 52% of the approximately 36,000 total U.S. casualties over a nine-year period during Operation Iraqi Freedom and Operation Enduring Freedom occurred from hostile attacks during land transport missions, mainly associated with resupplying fuel and water." *See also* Army Environmental Policy Institute, *Sustain the Mission Project: Casualty Factors for Fuel and Water Resupply Convoys Final Technical Report* (Sept. 2009) (*available at* https://apps.dtic.mil/dtic/tr/fulltext/u2/b356341.pdf).
[48] *See, e.g.,* Department of Energy, *Nuclear Energy University Program* (*available at* https://www.energy.gov/ne/nuclear-reactor-technologies/nuclear-energy-university-program). Since 2009, the Nuclear Energy University Program has awarded "approximately $290 million to 89 colleges and universities in 35 states and the District of Columbia to train the next generation of nuclear engineers and scientists in the United States and continue U.S. leadership in clean energy innovation."
[49] *See* Energy Futures Initiative and the National Association of State Energy Officials, U*.S. Energy and Employment Report*, at 108, 113 and 119 (2020) (*available at* https://www.usenergyjobs.org/); American Nuclear Society, *The U.S. Nuclear R&D Imperative: A Report of the American Nuclear Society Task Force on Public Investment in Nuclear Research and Development*, at 13 (Feb. 2021) (*available at* https://www.ans.org/file/3177/2/ANS%20RnD%20Task%20Force%20Report.pdf); U.S. Department of Energy, Office of Nuclear Energy, *Advantages and Challenges of Nuclear Energy* (Jan. 26, 2021) (*available at* https://www.energy.gov/ne/articles/advantages-and-challenges-nuclear-energy#:~:text=Creates%20Jobs,higher%20than%20the%20local%20average).

sources over less land. And while renewable energy sources like solar and wind will play an important role in our clean energy framework, nuclear energy provides a unique, efficient and reliable solution. As previously noted, a recent report estimates that based on future carbon mitigation goals, the U.S. nuclear market revenues could amount $2 trillion over the next 30 years, and the global market could reach over $8 trillion.[50] But even just looking at today's market, we know new nuclear projects are already resulting in hundreds of billions of dollars in global market opportunities. This growth and development is further spurred by the current focus, both domestically and abroad, on combatting climate change.

- **Reliable, Low-Carbon Process Heat:** Nuclear energy may be the only reliable zero-carbon source of industrial process heat in desalination, oil refining, ethanol production, and the like. The industrial sector contributes around 28% of global greenhouse gas emissions and its decarbonization will cost anywhere between $11 trillion and $21 trillion.[51] Using nuclear in place of current energy alternatives in process heat applications can result in price stability, no carbon emissions, and increased security.[52] Besides its proven value in industrial processes, nuclear can also be used to create power generation sources, like hydrogen, for decarbonization. For example, heat from high-temperature nuclear reactors can potentially provide energy necessary for electrolysis, which can be used to make hydrogen production more efficient.[53] Future high-temperature reactors may also be used to make hydrogen thermochemically.[54]

- **U.S. Leadership and R&D:** Investing in the nuclear innovation also adds value to the U.S. research mission by providing engineers and scientists resources for research, supporting our National Laboratories, universities, and staying on top of technology innovation.[55] The research resulting from nuclear reactors at leading U.S. universities and the National Laboratories has numerous spin-offs for other disciplines, such as superconductors, polymers, metals, and proteins.[56] Nuclear technology also aids in determining quality control for aerospace, automotive, and medical components.

---

[50] UxC, LLC, *Global Nuclear Market Assessment Based on IPCC Global Warming of 1.5° C Report* (Jul. 2020) (*available at* https://www.nei.org/CorporateSite/media/filefolder/resources/reports-and-briefs/UxC-NEI-(IPCC-2050-Nuclear-Market-Analysis-PUBLIC)-2020-07-01.pdf).
[51] McKinsey, *Decarbonization of industrial sectors: the next frontier* (Jun. 2018) (*available at* https://www.mckinsey.com/business-functions/sustainability/our-insights/how-industry-can-move-toward-a-low-carbon-future).
[52] World Nuclear Association, *Nuclear Process Heat for Energy* (Sept. 2020) (*available at* https://www.world-nuclear.org/information-library/non-power-nuclear-applications/industry/nuclear-process-heat-for-industry.aspx).
[53] *Id.*
[54] World Nuclear Association, *Hydrogen production and uses* (Feb. 2021) (*available at* https://www.world-nuclear.org/information-library/energy-and-the-environment/hydrogen-production-and-uses.aspx).
[55] U.S. Nuclear Regulatory Commission, *Backgrounder on Research and Test Reactors* (last updated May 5, 2020) (*available at* www.nrc.gov/reading-rm/doc-collections/fact-sheets/research-reactors-bg.html).
[56] *Id.*

- **<u>Safety and Non-Proliferation Leadership</u>**. Promoting U.S. nuclear technology globally will also help ensure high standards for safety and nonproliferation continue in place to the benefit of our children.[57] The U.S. has lead in setting the safety and security standards that have made nuclear power so safe around the world. We have an incredibly robust regulator, the U.S. Nuclear Regulatory Commission, that serves as a global "Gold Standard" for nuclear regulators around the world and which helps advise other countries on regulatory oversight. The U.S. exports its strict nuclear governance standards and governance culture—including the critically important Nuclear Safety Culture—when it works abroad, helping to ensure plants are run safe. When countries work with the U.S., they agree to strict commitments on the sharing of nuclear technology (i.e., U.S. 123 Agreements); adopt U.S. operational safety standards (e.g., those promulgated by the U.S. Institute of Nuclear Power Operations, which are further re-enforced with the World Association of Nuclear Operators standards); and set forth a global fuel supply framework that reduces risk of proliferation.

- **<u>U.S. National Security</u>:** The U.S. Navy has a command of the sea that affords the United States unrivaled international influence, due to the nuclear reactors powering its aircraft carriers and submarines. For decades, the size and sophistication of ships nuclear reactors can support have enabled leaders in Washington to project American power over much of the earth, during times of both war and peace.[58] New reactor designs that are likely to move naval vessels faster and more efficiently. Indeed, China is building a molten salt reactor (a new type of advanced nuclear reactor) for potential application on aircraft carriers for naval population and flying drones.[59] Beyond the high seas, as discussed above advanced reactors can deploy at forward operating bases to provide reliable power in war zones or distant locations, and eliminate fuel delivery-related deaths.

- **<u>Leadership in Space</u>:** Nuclear power itself is a key component of extra-orbital space research. For example, the Voyager spacecraft[60] and the Mars rover, Curiosity, use Radioisotope Thermoelectric Generators (RTGs) to continue to function.[61] According to a recent report by the National Academies of Sciences, Engineering, and Medicine, both nuclear thermal propulsion (NTP) and nuclear electric propulsion (NEP) systems "show great potential" in the realm of space exploration, particularly in a human exploration of

---

[57] Atlantic Council, *U.S. Nuclear Energy Leadership: Innovation and the Strategic Global Challenge, Report of the Atlantic Council Task Force on U.S. Nuclear Energy Leadership* (May 2019) (*available at* https://www.atlanticcouncil.org/wp-content/uploads/2019/05/US_Nuclear_Energy_Leadership-.pdf); *see* World Nuclear Association, *Nuclear Power in Russia* (last updated July 2020) (*available at* https://www.world-nuclear.org/information-library/country-profiles/countries-o-s/russia-nuclear-power.aspx).
[58] *See* Council on Foreign Relations, *Sea Power: The U.S. Navy and Foreign Policy* , by Jonathan Masters (Aug. 19, 2019) (*available at* https://www.cfr.org/backgrounder/sea-power-us-navy-and-foreign-policy).
[59] Michael Wallace, Amy Roma, and Sachin Desai, *Back from the Brink: A Threatened Nuclear Energy Industry Compromises National Security*, Center for Strategic and International Studies (Jul. 2018) (*available at* https://www.csis.org/analysis/back-brink-threatened-nuclear-energy-industry-compromises-national-security).
[60] NASA, *Voyager Spacecraft* (*available at* www.voyager.jpl.nasa.gov/mission/spacecraft/).
[61] NASA, *Radioisotope Power Systems* (*available at* www.rps.nasa.gov/).

Mars, although NASA and DOE must prioritize the development of such a mission if it is expected to come to fruition.[62]

V. Path Forward

This is a pivotal time for the U.S. energy innovation and the failure to recognize the case for advancing nuclear development with full-force Congressional support will be a major loss for this country. Innovative U.S. companies working hard on advanced nuclear technologies should not be tempted to develop their work abroad for a lack of support at home. Americans who have dedicated their careers to supporting the energy sector should not miss out on well-paying jobs because the U.S. could not recognize a major opportunity in a growing field in time. And global safety and security should not be compromised due to the U.S.'s inaction in leveraging its relationships with other countries for the common good. Supporting the existing nuclear fleet and providing the resources and backing necessary for advanced nuclear to thrive can help keep the U.S. as a forerunner in the nuclear industry globally.

With this incredible expanse of nuclear globally, U.S. innovation in nuclear power can stand up to state backed competitors. As discussed above, we saw this in the aerospace market when Russia ceded control of the global commercial launch industry due to the 1-2 punch of U.S. innovation (led by SpaceX) and U.S. government commercialization support (demonstrated through the NASA COTS program).[63]

There are many ways Congress can help support this industry, including by continuing to fund and support the Department of Energy's ADRP program, other R&D initiatives, moving forward on spent fuel disposal solutions, supporting the existing fleet and infrastructure, supporting efforts to streamline and improve the efficiency of NRC licensing and exports, supporting efforts to expand financing options for new nuclear projects, including through the Export/Import bank and Development Finance Corporation, just to name a few.

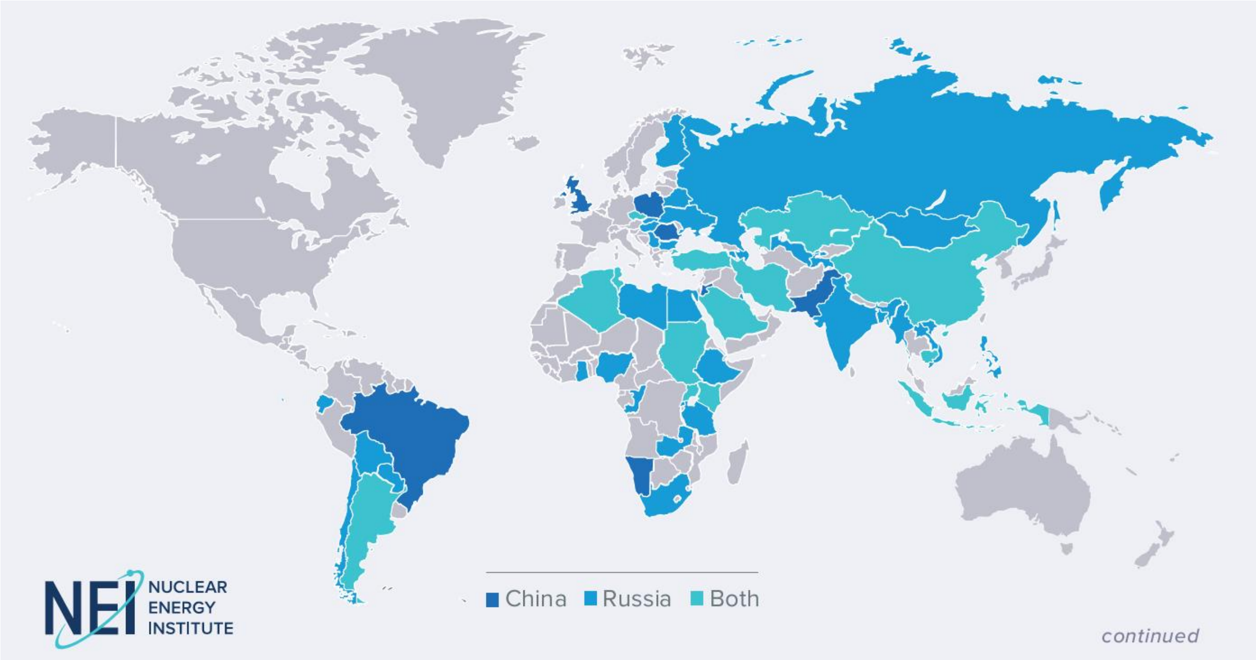
Thank you for the opportunity to testify before this Committee on the importance of nuclear power in our current and future energy structure.

---

[62] National Academies of Sciences, Engineering, and Medicine, *Nuclear Propulsion for Human Mars Exploration* (2021) (*available at* https://www.nationalacademies.org/our-work/space-nuclear-propulsion-technologies).
[63] Ars Technica, Russia appears to have surrendered to SpaceX in the global launch market (Apr. 18, 2018) (*available at* https://arstechnica.com/science/2018/04/russia-appears-to-have-surrendered-to-spacex-in-the-global-launch-market/).

Appendix A

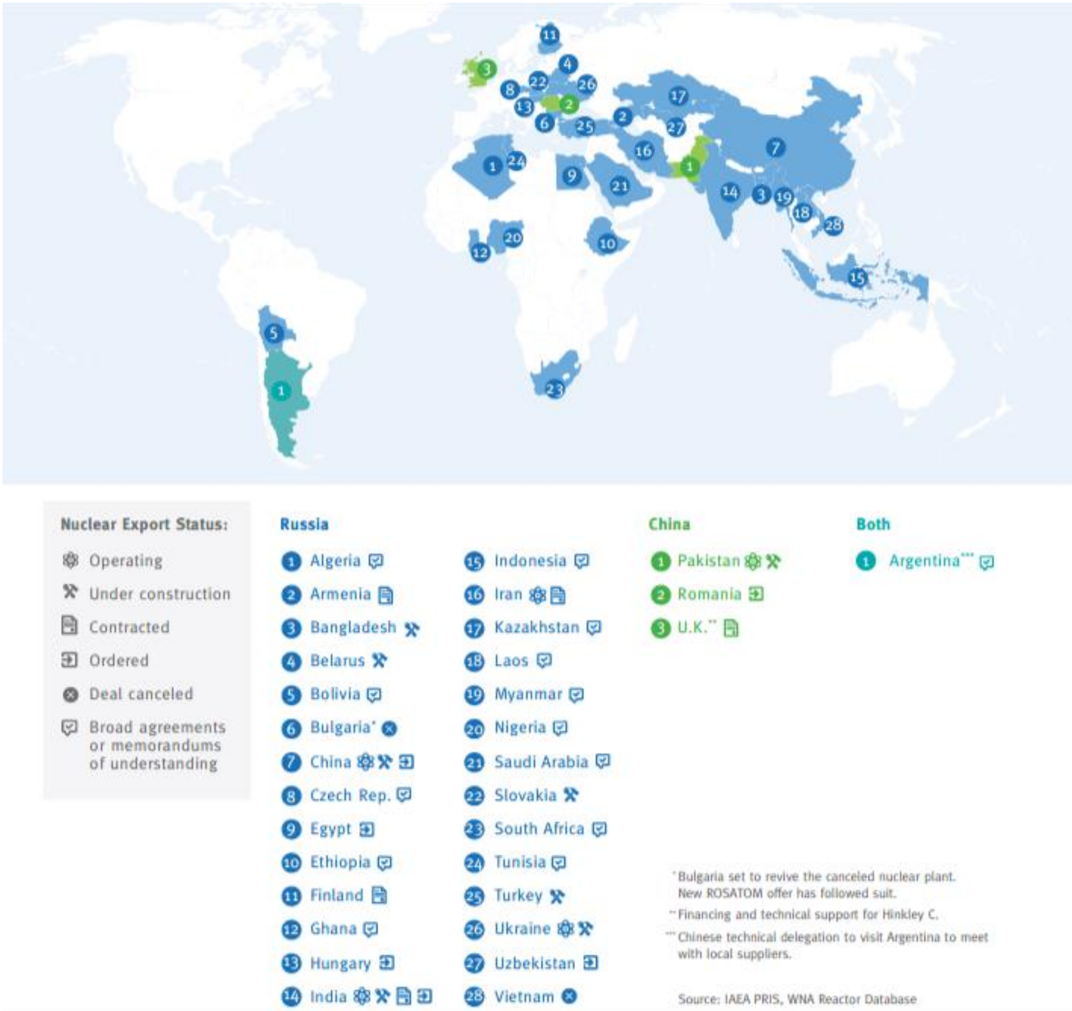
Map 1. Russia and China Global Presence



Source: Nuclear Energy Institute, 2020[64]

[64] Nuclear Energy Institute, *Russia and China Are Expanding Nuclear Energy Exports. Can the U.S. Keep Up?* (Oct. 6. 2020) (*available at* nei.org/news/2020/russia-china-expanding-nuclear-exports-us-keep-up).

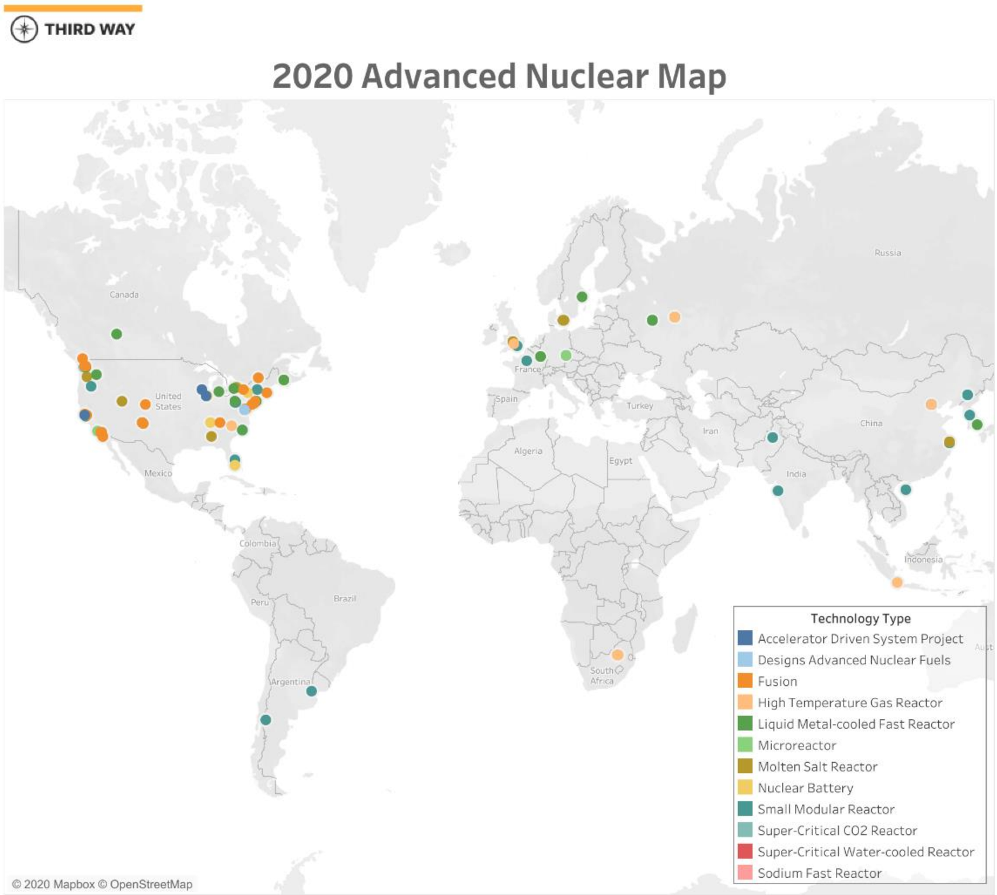
Map 2. Russian and Chinese LWR Export Targets



Source: Global Nexus Initiative, 2019[65]

[65] Global Nexus Initiative, *Responding to Climate Change and Strengthening Global Security* (2019) (*available at* https://globalnexusinitiative.org/results/reports/advancing-nuclear-innovation-responding-to-climate-change-and-strengthening-global-security/).

Attachment B
Map 1. Global Advanced Nuclear Technology Development



Source: Third Way, 2020.[66]

[66] Third Way, *2020 Advanced Nuclear Map: Progress Amidst a Tumultuous Year* (Dec. 21, 2020) (*available at* https://www.thirdway.org/graphic/2020-advanced-nuclear-map-progress-amidst-a-tumultuous-year).