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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 Subcommittees. This testimony represents my observations and in no way represents the views of the Atlantic Council, Hogan Lovells or its clients.

I. SETTING THE STAGE

A. A high stakes history lesson

Understanding the importance of commercial nuclear power—and therefore the importance of the Department of Energy's Office of Nuclear Energy (DOE-NE) and the activities it undertakes—begins with a history lesson that underscores the unique tool nuclear energy can give the U.S. both domestically and on the global stage.

Commercial nuclear energy and the United States government share a long history that is intertwined with the global struggle for peace and security.[1] 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 policy of nonproliferation.[2]

In response, the U.S. government in the 1950s saw the value that peaceful use of nuclear energy 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

[1] 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.

[2] 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.")

weapons.[3] This program, known as "Atoms for Peace," resulted in three important economic and national security objectives because it made the U.S. the leader in nuclear power: (1) it prevented the spread of nuclear weapons because the U.S. led and thus had oversight over global peaceful nuclear energy development and the terms under which technology was shared; (2) it ensured 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.

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 energy 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 will undermine U.S. influence, as well as U.S. safety and nonproliferation standards.

Under today's current climate, Russia and China have identified building nuclear energy plants and nuclear trade as national priorities promoted by the highest levels of government and backed by state financing and state-owned enterprises and are aggressively pursuing the global market. Their focus has paid off. Russia now dominates nuclear energy 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 both the largest domestic producer of nuclear power,[4] but also emerge as a close competitor to Russia for international new nuclear projects.[5] The struggling U.S. nuclear energy 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.

But while we have lost our leadership in supplying reactors around the world, we have a chance to regain it again with the development of advanced reactors—which DOE-NE is critical in supporting. The U.S. leads the world in the development of advanced fission reactors, as well as the nascent fusion industry. If the United States leads in implementing this new technology

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[3] 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).

[4] Nikkei Asia, *China poised to overtake US in nuclear energy 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; Council on Foreign Relations, *Independent Task Force Report No. 79, China's Belt and Road, Implications for the United States*, updated Mar. 2021 [hereinafter CFR Task Force Report], available at https://www.cfr.org/report/chinas-belt-and-road-implications-for-the-united-states/ (explaining: "Though principally aimed at developing countries, with Pakistan, Malaysia, Bangladesh, Myanmar, and Sri Lanka among the largest recipients of BRI funds, BRI also includes developed countries, with numerous U.S. allies participating.") *See also* Organization for Economic and Cooperation and Development (OECD) Business and Finance Outlook 2018, *China's Belt and Road Initiative in the Global Trade, Investment and Finance Landscape*, available at https://www.oecd.org/finance/Chinas-Belt-and-Road-Initiative-in-the-global-trade-investment-and-finance-landscape.pdf.

[5] *China could build 30 'Belt and Road' nuclear reactors by 2030: official*, Reuters (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.

wave, safety will improve, our geopolitical relationships will strengthen, and non-proliferation will remain strong. However, if U.S. companies do not receive U.S. government support these benefits will fall to the wayside and other countries will emerge as leaders. We currently are well-positioned to deliver advanced reactor but we again have Russia and China close at our heels and need to work strategically to maintain our lead as advanced reactors come to the global market.

In addition to the historical importance of nuclear power, four other key benefit have emerged around climate change and energy growth that make the global market even more important:

- Nuclear energy is a non-greenhouse gas emitting power generation source, and a crucial tool in the battle against climate change;

- It has the ability to provide clean, affordable, and reliable power around the world, helping raise the global standard of living,[6] including for the approximately 860 million people in the world with no access to electricity;

- The world electricity demand is expected to double globally by 2050,[7] presenting a huge market opportunity for the U.S.; and

- Advanced reactors have a wide range of sizes and applications beyond power generations, and can help decarbonize the industrial sector, desalinate water, produce hydrogen, keep the U.S. at the forefront of travel by space and sea.

While U.S. innovation can turn the tide at home and abroad, just as SpaceX reclaimed the global launch market from Russia, until electrons are added to the grid, the U.S. will fall behind and risk losing hundreds of millions of dollars in revenues, and job opportunities for tens of thousands of Americans. I walk through these issues in further detail below.

B. Nuclear energy in the U.S. today

Nuclear boasts attractive features that routinely garner bipartisan support and is currently 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 of electricity. 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 93 reactors, operated by 30 different power companies across 30 different states.[8]

The nuclear industry supports nearly half a million jobs in the United States and contributes about $60 billion to the U.S. GDP annually.[9] Current nuclear energy plants can employ up to 700 workers with salaries that are 30% higher than the local average, and they contribute billions of

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[6] *See, e.g.*, HL New Nuclear Blog, *IPCC Report Underscores Need for Nuclear for Rapid Decarbonization*, https://www.hlnewnuclear.com/2021/08/ipcc-report-underscores-need-for-nuclear-for-rapid-decarbonization/.

[7] 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.

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

[9] DOE-NE, *Advantages and Challenges of Nuclear Energy* (Mar. 29, 2021), available at https://www.energy.gov/ne/articles/advantages-and-challenges-nuclear-energy.

dollars annually to local economies through federal and state tax revenues.[10] In addition to providing large amount of carbon free power,[11] nuclear power plants also operate incredibly well, providing reliable power with an average capacity factor[12] of over 90% (compared with intermittent power sources such as wind (about 35% capacity factor) and solar PV (about 25% capacity factor)).[13]

Almost all the U.S. nuclear operating today comes from reactors built between 1967 and 1990. As recently as 2013, the U.S. had 104 operating domestic nuclear energy reactors, but the number has decreased to around 93 today, and about 1/3 of them are facing economic hardships due largely to the long-term decline in natural gas prices beginning around 2008 the led first to a number of cancelled planned plants and then to the premature shutdown of a number of operating plants.[14] While two new plants are under construction, no other large scale units are planned after this time.

Despite these challenges, U.S. reliance on nuclear energy has grown, with U.S. nuclear generation capacity doubling because of increased operational efficiencies and power uprates.[15] The U.S. nuclear industry has also achieved remarkable gains in power plant utilization. A number of states have moved to keep economically troubled nuclear energy plants open to preserve their low carbon attributes, using a "Social Cost of Carbon" metric to support the cost-benefit analyses of the programs, but these are intended to be a stop gap measures until a more permanent solution emerges.[16] At the current rate, more nuclear energy plants are expected to prematurely shutdown, leading to a significant degradation of the existing fleer and reduction in a large amount of carbon-free power.

II. ADVANCED REACTORS ARE ON THE CUSP ON DEPLOYMENT AND CAN SUPPORT A WIDE RANGE OF U.S. INTERESTS

A. A summary of the benefits of advanced reactors

The U.S. excels at technological innovation—both in developing nuclear energy technology and innovating it. Advanced reactors are no exception. In the near term, advanced reactors are the only new planned projects to join the nuclear energy mix in the United States and they are well poised to give the U.S. an opportunity to regain its global nuclear leadership and give us a strong tool in the fight against climate change—and there are dozens of ventures poised to enter the market in the advanced reactor space. This innovation can bring jobs, support the U.S.

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[10] *Id.*

[11] As used herein, "carbon free" means nuclear power generation does not emit carbon dioxide or other greenhouse gases.

[12] 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.

[13] 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.

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

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

[16] 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/.

economy and, and keep the U.S. at the cusp of technological advancements to support a range of interests, including international trade, decarbonization, space exploration, and geopolitical and national security interests.

Many advanced reactors contain enhanced safety systems, such as passive safety features and below grade construction, and would be able to support a wide range of applications that include not only power generation—from the tiny to the large, and everything in between--but also 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.[17]

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

In particular, advanced reactors offer great promise for actualizing a true Nuclear Renaissance. There are several dozen domestic ventures in next-generation nuclear technologies and new opportunities are being created every day (*see* Appendix B, for a global perspective of advanced nuclear development, showing significant activity in the United States).[18] These endeavors take many forms. Some hope to use liquid metal coolants, some want to use pebble-bed reactors with gaseous helium coolant, and some want to greatly improve current light water reactor designs. Some want to have liquid uranium fuel, and some want to use nuclear waste as fuel. Some propose to cut out fission altogether and move straight to nuclear fusion. Nearly all of them offer modular designs that can start small and scale with customer needs. And along with the advanced fission reactors under development, there are also a number of fusion ventures looking to demonstrate and commercialize fusion power technologies.[19]

Listed below are just some of the benefits nuclear can provide the U.S. if adequately supported:

- **High-Paying Jobs.** Investment in nuclear energy 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. Additionally, tens of thousands of STEM jobs are required to support nuclear plant operation. These positions open the door for highly skilled domestic employees, many of whom come to the field from the

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[17] *See, e.g.*, World Nuclear Association, *Nuclear Process Heat for Industry* (Updated Sept. 2021), 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 May 2021), available at https://www.world-nuclear.org/information-library/non-power-nuclear-applications/transport/nuclear-reactors-for-space.aspx.

[18] 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.

Navy or after pursuing extensive university programs.[20] In fact, nuclear energy 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).[21]

- **Low-Carbon Power.** Nuclear energy is an effective solution to help combat greenhouse gas emissions, while also producing more energy than alternative renewable sources and requiring far less land to produce a comparable amount of energy. Over half of zero-carbon emission electricity in the U.S. is generated by nuclear power, and the utilization of nuclear energy has prevented the emission of 528 million metric tons of carbon dioxide emissions.[22] Nuclear energy is an important tool in the toolbox of no- and low-carbon electricity. And while renewable energy sources like solar and wind may play an important role in our clean energy framework, nuclear energy provides a more efficient and reliable solution.

  A recent report estimates that based on future carbon mitigation goals, the U.S. nuclear market revenues could amount to $1.9 trillion over the next 30 years.[23] This growth and development is further spurred by the current focus, both domestically and abroad, on achieving a zero-carbon future. Commercializing advanced nuclear technology in the industrial sector can help facilitate climate-conscious policies, such as those influencing the industrial sector. The industrial sector contributes around 28% of global greenhouse gas emissions and its decarbonization will cost anywhere between $11 trillion and $21 trillion.[24] This massive effort will require strategic utilization of various front-line technologies, like those being developed in the nuclear space. Decarbonization will require and "all of the above" approach in order to ensure energy diversity and security.

- **Grid Security and Independence.** At the same time we need to decarbonize the grid, we need to make sure the lights stay on. Ironically, abnormal weather conditions—such as the kind we keep seeing linked to climate change—can lead to elevated risks to the grid—affecting both generation and demand, as well as causing energy shortages that

[20] *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."
[21] *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.usenergy jobs.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.
[22] Nuclear Energy Institute, Climate webpage, available at https://www.nei.org/advantages/climate.
[23] 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.
[24] McKinsey, *Decarbonization of industrial sectors: the next frontier* (June 2018), available at https://www.mckinsey.com/business-functions/sustainability/our-insights/how-industry-can-move-toward-a-low-carbon-future.

lead to energy emergencies. In addition to providing large amount of carbon free power, nuclear power plants also operate incredibly well. As noted above, it provides reliable power with an average capacity factor[25] of over 90% (compared with much lower capacity factors for all other power generation sources, including about 35% for wind and 25% for solar PV).[26] Meaning that nuclear power is a very reliable carbon-free power source.

When the lights go out not only does it have significant financial impacts, but it costs lives as well.[27] The recent Texas power crisis that occurred in February 2021 is an example of this.[28] As outlined in a recent report, when the storm hit this past winter, more than 4.5 million households were left without electricity during an extreme cold snap, with the storm and outages leading to the loss of over 100 lives and causing an economic loss estimated to be about $155 billion.[29]

- **Reliable, Low-Carbon Process Heat.** Nuclear energy is often the only reliable zero-carbon source of industrial process heat in desalination, oil refining, ethanol production, and the like. Using nuclear in place of current energy alternatives in process heat applications can result in price stability, no carbon emissions, and increased security.[30] Besides its proven value in industrial processes, nuclear can also be used to create power generation sources, like hydrogen, for decarbonization. Although still in the research stage, heat from high-temperature nuclear reactors can potentially provide energy necessary for electrolysis, which can be used to make hydrogen production more efficient.[31] Future high-temperature reactors may also be used to make hydrogen thermochemically.[32]

- **U.S. Leadership in R&D.** Investing in the nuclear sector also adds value to the U.S. research mission by providing engineers' and scientists' resources for research.[33] The research resulting from nuclear reactors at leading U.S. universities has numerous spin-offs for other disciplines, such as superconductors, polymers, metals, and proteins.[34]

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[25] 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.
[26] 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.
[27] HL New Nuclear Blog, *Grid Reliability Report Highlights Benefits of Pairing Advanced Nuclear with Renewables to Ensure Power Stays On* (Jun. 9, 2021), available at https://www.hlnewnuclear.com/2021/06/grid-reliability-report-highlights-benefits-of-pairing-advanced-nuclear-with-renewables-to-ensure-power-stays-on/.
[28] *Id.*
[29] Science Direct, *Cascading risks: Understanding the 2021 winter blackout in Texas* (Jul. 2021), available at https://www.sciencedirect.com/science/article/pii/S2214629621001997.
[30] World Nuclear Association, *Nuclear Process Heat for Energy* (Sept. 2021), available at https://www.world-nuclear.org/information-library/non-power-nuclear-applications/industry/nuclear-process-heat-for-industry.aspx.
[31] *Id.*
[32] World Nuclear Association, *Hydrogen production and uses* (Sept. 2021), available at https://www.world-nuclear.org/information-library/energy-and-the-environment/hydrogen-production-and-uses.aspx.
[33] U.S. Nuclear Regulatory Commission, *Backgrounder on Research and Test Reactors* (last reviewed Jan. 26, 2021), available at www.nrc.gov/reading-rm/doc-collections/fact-sheets/research-reactors-bg.html.
[34] *Id.*

Nuclear technology also aids in determining quality control for aerospace, automotive, and medical components. Nuclear energy itself is a key component of extra-orbital space research. For example, the Voyager spacecraft[35] and the Mars rover, Curiosity, use Radioisotope Thermoelectric Generators (RTGs) to continue to function.[36] And there are other applications for nuclear reactors as well, including propulsion for shipping and submarines, and power icebreakers. This is a technology that the U.S. needs to know, and we need to stay at the top of innovation in this space for not only commercial and economic purposes, but also to support our own national defense.

- **National Security.** Nuclear application in the naval and space industries is becoming more necessary with time. New nuclear reactors and technologies will be needed to support the U.S. military, such as the U.S. Navy's nuclear propulsion program, the Department of Defense's microreactor project for forward operating bases, energy independence for U.S. military bases, and future air and space travel. For example, the U.S. Navy has a command of the sea that affords the United States unrivaled international influence. For decades, its size and sophistication have enabled leaders in Washington to project American power over much of the earth, during times of both war and peace.[37] If the U.S. expects to maintain a strong naval presence, then it must prioritize new reactor designs that are likely to move naval vessels faster and more efficiently; otherwise, the U.S. risks falling behind other countries that are already working on such developments.

- **Leadership in Space.** Similarly, continued research in nuclear thermal propulsion (NTP) and nuclear electric propulsion (NEP) is necessary to develop capabilities of space exploration undergirded by nuclear power. This includes research on fuel options, including high-assay, low-enriched uranium fuels and highly enriched uranium. According to a recent report by the National Academies of Sciences, Engineering, and Medicine, both NTP and NEP systems "show great potential" in the realm of space exploration, particularly in a human exploration of Mars, but NASA and DOE must prioritize the development of such a mission if it is expected to come to fruition.[38]

Below, I walk through how DOE-NE supports advanced reactor deployment, as well as more detail on the climate change benefits of nuclear power and U.S. interest in deploying advanced reactors abroad.

B. Value of DOE-NE is supporting advanced reactors' deployment

DOE-NE has been key to supporting technology innovation and commercialization in the advanced reactor space. One of the most important programs is DOE-NE's Advanced Reactor Demonstration Program (ARDP)—because demonstration is pivotal to supporting widespread deployment in the commercial markets both in the U.S. and abroad.

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[35] NASA, *Voyager Spacecraft*, available at www.voyager.jpl.nasa.gov/mission/spacecraft/.
[36] NASA, *Radioisotope Power Systems*, available at www.rps.nasa.gov/.
[37] *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.
[38] 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.

The ARDP is intended to speed the demonstration of advanced reactors through 50-50 cost-shared partnerships with U.S. industry. ARDP applicants can receive support through three different development and demonstration pathways:[39]

- **Advanced Reactor Demonstrations Projects**, which are expected to result in a fully functional advanced nuclear reactor by the end of 2027. DOE-NE has selected two awardees under this program. Congress appropriated $160 million for the Fiscal Year 2020 budget as initial funding for this program.

- **Risk Reduction for Future Demonstrations**, which will support up to five additional teams resolving technical, operational, and regulatory challenges to prepare for future demonstration opportunities. The goal of the Risk Reduction program is to design and develop safe and affordable reactor technologies that can be licensed and deployed over the next 10 to 14 years. DOE-NE has selected five awardees under this program. Congress appropriated $30 million in Fiscal Year 2020 for this program.

- **Advanced Reactor Concepts 2020 (ARC 20)**, which will support innovative and diverse designs with potential to commercialize in the mid-2030s. The goal of the ARC-20 program is to assist the progression of advanced reactor designs in their earliest phases. DOE-NE has selected three awardees under this program. Congress appropriated $20 million in Fiscal Year 2020 for this program.

Funding beyond the near-term is contingent on additional future appropriations, evaluations of satisfactory progress and DOE-NE approval of continuation applications.[40]

On October 13, 2020, the U.S. Department of Energy awarded X-energy and TerraPower $80 million each for their respective initiatives to build advanced nuclear reactors by 2027 under the ARDP demonstration arm. The initial award is for $80 million but DOE-NE has stated that it will invest a total of $3.2 billion over seven years, subject to the availability of future appropriations, with the industry partners providing matching funds, for these projects.[41]

Under its ARDP demonstration award, X-energy plans to deliver a commercial four-unit nuclear energy plant based on its Xe-100 reactor design. According to X-energy, the Xe-100 is a high temperature gas-cooled reactor that is ideally suited to provide flexible electricity output as well as process heat for a wide range of industrial heat applications, such as desalination and hydrogen production. The project also includes a commercial scale TRi-structural ISOtropic particle fuel (TRISO) fuel fabrication facility, supporting DOE-NE's interest in the development of TRISO fuel.[42]

Under its ARDP demonstration award, TerraPower plans to demonstrate the Natrium reactor, a sodium-cooled fast reactor that leverages of decades of development and design undertaken by TerraPower and its partner, GE-Hitachi. According to TerraPower, the high-operating temperature of the Natrium reactor, coupled with thermal energy storage, allows the

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[39] DOE-NE, *ARDP*, available at https://www.energy.gov/ne/advanced-reactor-demonstration-program.
[40] DOE-NE, *U.S. Department of Energy Announces $160 Million in First Awards under Advanced Reactor Demonstration Program*, (Oct. 13, 2020), available at https://www.energy.gov/ne/articles/us-department-energy - announces-160-million-first-awards-under-advanced-reactorailable.
[41] *Id.*
[42] *Id.*

plant to provide flexible electricity output that complements variable renewable generation such as wind a solar. This project will also establish a new metal fuel fabrication facility that is scaled to meet the needs of this demonstration program.[43]

X-energy has announced its intent to build its first facility in Washington state under the ARDP award. TerraPower has announced its intent to build its first facility in Wyoming, at a retired coal plant site.

On December 16, 2020, DOE-NE announced the selections of five teams to receive $30 million in FY2020 funding under ARDP's Risk Reduction for Future Demonstration program.[44] DOE-NE's estimated long terms support for this program is about $600 (subject to appropriations). One of the awardees under this branch of the ARDP, Kairos Power, recently submitted the technical portion of its NRC application for a test reactor to demonstrate its advanced reactor technology.[45]

Finally, in December 2020, DOE-NE announced the recipients of the ARC 20 awards.[46] These provide $20 million in awards for the third of the ARDP programs. For the ARC-20 projects, DOE-NE expects to invest a total of approximately $56 million over four years with industry partners providing at least 20 percent in matching funds.

In addition to the ARDP, DOE-NE has provided support for the NuScale project, a next generation light-water reactor and now NRC certified design, and a planned power project for a 12-module NuScale power plant to be located at Idaho National Laboratory.

DOE-NE also offers other critical support for nuclear innovation, including through the Gateway for Accelerated Innovation in Nuclear (GAIN) program, which provides the private sector with access to R&D at our National Laboratories; its support for investing in the next generation of nuclear energy leaders and advancing university-led nuclear innovation under DOE-NE's Nuclear Energy University Program; support for the Versatile Test Reactor, a new research reactor that will be capable of performing irradiation testing at much higher neutron energy fluxes than what is currently available today and which is critical for domestic materials testing, among other things; international collaboration and engagements; and R&D support. DOE-NE is also supporting the Department of Defense on Project Pele, which is working with a couple advanced reactor 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]

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[43] *Id.*

[44] DOE-NE, *Energy Department's Advanced Reactor Demonstration Program Awards $30 Million in Initial Funding for Risk Reduction Projects*, (Dec. 16, 2021), available at https://www.energy.gov/ne/articles/energy -departments-advanced-reactor-demonstration-program-awards-30-million-initial.

[45] World Nuclear News, *Kairos submits PSAR for Oak Ridge demonstration reactor* (Oct. 5, 2021), available at https://www.world-nuclear-news.org/Articles/Kairos-submits-PSAR-for-Oak-Ridge-demonstration-re.

[46] DOE-NE, *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 -departments-advanced-reactor-demonstration-program-awards-20-million-advanced.

[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://energy post.eu/u-s-militarys-mobile-mini-nuclear-fewer-fuel-supply-convoys-mean-fewer-casualties/); *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. "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

DOE-NE is also providing support for fuels for advanced reactors. There's a pressing need for high-assay low enriched uranium (HALEU) for fuel for advanced reactors and it is not commercially available. The nuclear industry anticipates it may need nearly 600 metric tonnes of HALEU by 2030 in order to deploy new reactors to the market.[48] DOE-NE is exploring both near term and long terms option to support the development of HALEU fuel for advanced reactors.[49]

The development of advanced reactors, supporting by DOE-NE, will provide support for proving that advanced reactors can meet the promises they offer—including providing jobs, domestic and global economic opportunity, and large abouts of carbon free power.

III. A DEEPER DIVE: CLIMATE CHANGE AND U.S. INTERESTS IN THE GLOBAL MARKET

A. Deployment of advanced reactors provide a strong tool in combatting climate change

Nuclear energy, including both current operating nuclear technologies and advanced reactor technology, plays a critical role in the fight against climate change.

The United Nations Intergovernmental Panel on Climate Change (IPCC) released its sixth assessment report (IPCC Report) on August 9, 2021 saying that climate change is widespread, rapid, and intensifying, which likely did not come as a surprise to anyone.[50] What was surprising, however, was how confident the report was in its key messages, including the following:

- **Climate change is humans' fault**. It is "unequivocal" that human activity has caused global warning, causing rapid and widespread warming of the atmosphere, ocean, and land.

- **Climate change is happening faster than we thought.** Global warming was happening faster than previously anticipated, and global surface temperatures will continue to increase unless deep reductions in carbon dioxide and other greenhouse gas emissions occur in the coming decades.

- **World carbon dioxide levels are at an all-time high**. Carbon dioxide levels were greater in 2019 than they had been in at least two million years. Methane and nitrous oxide levels, the second and third major contributors of warming respectively, were higher in 2019 than at any point in at least 800,000 years.

- **Changes like this to the climate system haven't happened in thousands of years**. The scale of recent changes across the climate system is unprecedented—going back hundreds and thousands of years as to global surface temperature, Arctic ice area, and rise of sea level.

Enduring Freedom occurred from hostile attacks during land transport missions, mainly associated with resupplying fuel and water."

[48] DOE-NE, *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.

[49] *Id.*

[50] IPCC Report, available at https://www.ipcc.ch/report/ar6/wg1/.

- **Every place on the planet is being affected right now.** Climate change has impacting every region of the world. Evidence of observed changes in extreme weather includes heatwaves, heavy rains, droughts, and stronger tropical storms, just since the last IPCC Report seven years ago. Many changes in the climate system have become larger in direct relation to increasing global warming—making these already intensifying events ever more intense.

- **Many changes cannot be reversed for thousands of years.** Barring geoengineering, many changes due to past and future greenhouse gas emissions will be irreversible for centuries to millennia, especially changes to the ocean, ice sheets and global sea level.

But like Pandora's Box, after all the bad news, there was still a message of hope– *it's not too late to slow down and eventually reverse the most harmful effects of climate change, but the world has a lot to do and must act immediately*.

Notably, if the world undertakes strong and sustained reductions in emissions of carbon dioxide and other greenhouse gases, the impacts of climate change can be limited. While benefits for air quality would come quickly, it could take another 20-30 years to see global temperatures stabilize. The general global goal is net zero carbon emissions by 2050.[51] For the U.S, these goals also includes cutting greenhouse gas emissions by half by 2030, making the electricity grid carbon neutral by 2035, and reaching a reaching net zero emissions economy-wide by no later than 2050.[52]

While new technologies are needed to help combat climate change—such as advanced battery storage systems to pair with intermittent renewables like wind and solar—the U.S. and the world have an incredibly powerful tool for decarbonization already available to maintain and deploy: nuclear power.

In looking at the big picture:

- **Cleaning the current energy sector will be an immense task.** Decarbonization is not going to be an easy task. The electricity sector itself accounts for about 25 percent of both the U.S. and global total[53] emissions, with fossil fuel providing more than 60 percent of electricity[54] generated in the United States and globally.[55] Beyond the grid, decarbonizing other sectors—such as transportation (29% of U.S. emissions) and industry (23% of U.S. emissions)—will require access to both new clean technologies

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[51] UN News, *What is net zero and why is it important?* (Dec. 2, 2020), available at https://news.un.org/en/story/2020/12/1078612.

[52] White House, *Fact Sheet: President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target Aimed at Creating Good-Paying Union Jobs and Securing U.S. Leadership on Clean Energy Technologies* (Apr. 22, 2021), available at https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/22/fact-sheet-president-biden-sets-2030-greenhouse-gas-pollution-reduction-target-aimed-at-creating-good-paying-union-jobs-and-securing-u-s-leadership-on-clean-energy -technologies/.

[53] U.S. Environmental Protection Agency, *Sources of Greenhouse Gas Emissions*, available at https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions.

[54] U.S. Energy Information Administration (U.S. EIA), *Frequently Asked Questions*, available at https://www.eia.gov/tools/faqs/faq.php?id=427&t=3.

[55] Our World in Data, *Electricity Mix*, available at https://ourworldindata.org/electricity-mix#:~:text=In%202019%2C%20almost%20two%2Dthirds,and%20nuclear%20energy %20for%2010.4%25.

(such as batteries for vehicles) and new sources of energy to power those clean technologies.

- **Energy use is expected to double at the same time it needs to be decarbonized.** At the same time the world needs to decarbonize the energy sector, there will also be a huge uptick in demand—with the Energy Information Agency estimating a 50% increase in world energy use by 2050.[56] There are also nearly a billion people in the world without access to electricity.[57] So, not only does the world need to decarbonize the energy sector we have, when we build new energy sources to meet the increased demand, they need to be non-carbon emitting.

- **Decarbonization will not succeed if the lights do not stay on.** At the same time we need to decarbonize the grid, we need to make sure we have reliable power. As explained above, power outages cause immense safety and economic harms.

The IPCC report makes clear that we need to use everything in our arsenal to reduce greenhouse gas emissions. Moreover, we need immense sources of energy that do not produce greenhouse gases, that support a reliable electricity grid.

Nuclear energy fits this bill as a very powerful tool to be used to combat climate change, but is an often overlooked part of the climate change solution. As explained herein, advanced reactors in the U.S. are on the brink of deployment, showing that nuclear energy can play a key role in the energy transition from fossil fuels.[58] Advanced reactors, which produce process heat, can decarbonize the electric grid as well as heavy industry (which accounts for 23% of U.S. emissions itself).[59]

And along with the existing fleet of nuclear energy plants and advanced reactors, the world is on the brink of commercializing fusion power.[60] Fusion, the process that powers the Sun, has long been seen as the "holy grail" of energy production. Whereas nuclear reactors split atoms apart to release energy , fusion facilities push them together. A key trait that they each share is the ability to produce an immense amount of electricity without emitting carbon dioxide and other greenhouse gases.

As the world's largest producer of nuclear power, accounting for more than 30% of worldwide nuclear generation,[61] and the second largest greenhouse gas emitting country,[62] the

[56] U.S. EIA, *Today in Energy* (Sept. 24, 2019), available at https://www.eia.gov/todayinenergy /detail.php?id=41433.
[57] International Energy Agency, *Access to electricity*, available at https://www.iea.org/reports/sdg7-data-and-projections/access-to-electricity.
[58] HL New Nuclear Blog, *Advanced Nuclear Energy can Support a Just Transition for Communities that were Reliant on Coal* (Apr. 30. 2021), available at https://www.hlnewnuclear.com/2021/04/advanced-nuclear-energy -can-support-a-just-transition-for-communities-that-were-reliant-on-coal/.
[59] U.S. EPA, *Sources of Greenhouse Gas Emissions*, available at https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions.
[60] Amy Roma and Sachin Desai, *The Regulation of Fusion – A Practical and Innovation-Friendly Approach* (Feb. 14, 2020), available at https://www.hoganlovells.com/en/publications/the-regulation-of-fusion-a-practical-and-innovation-friendly-approach.
[61] World Nuclear Association, *Nuclear energy in the USA* (Sept. 2021), available at https://world-nuclear.org/information-library/country-profiles/countries-t-z/usa-nuclear-power.aspx
[62] U.S. EPA, *Sources of Greenhouse Gas Emissions*, available at https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions.

U.S. has a responsibility to promote innovation and deployment of technologies that can meaningfully combat climate change. That includes, at a minimum, making sure nuclear energy is part of the discussion and part of the solution for combatting climate change.

B. Nuclear reactors are being built all over the work and U.S. interests are supported by the U.S. participation in this market.

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.[63] There are also a number of advanced reactor technologies under development—about 130 in total—using cutting-edge technologies and capabilities (*see* Appendix B).[64]

And this is just the beginning, according to experts, the market for nuclear could triple by 2050 and generate $400 billion of electricity annually.[65] According to the Department of Commerce, 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.[66] If carbon mitigation measures are deployed, the 30-year cumulative market domestic opportunity for nuclear energy could reach up to $2 trillion, within a global market valued at around $8.6 trillion.[67]

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.[68] This is what the competition is doing. While globally, nuclear energy is taking off, using traditional large light water reactor technology offerings, 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, in order to realize the economic and geopolitical benefits of having their customers dependent on Russian and Chinese-managed energy resources.

Russia dominates the global nuclear new build marketplace, and has secured 60% of nuclear reactor sales around the world.[69] China planning on coming up close on its heels.[70] China has built almost half of all nuclear reactors constructed since 2000 and has designed numerous others outside its borders.[71] Nuclear development in these competitor countries are government-

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[63] 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.

[64] 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.

[65] 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.

[66] Nuclear Energy Institute, *Nuclear Exports & Trade Overview*, available at https://www.nei.org/advocacy/compete-globally.

[67] *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.

[68] Breakthrough Energy , *Advancing the Landscape of Clean Energy Innovation* (Feb. 2019), available at https://www.breakthroughenergy.org/reports/advancing-the-landscape/.

[69] 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.

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

[71] 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.

backed, providing the respective countries' nuclear industry with financial, political and regulatory support, making it almost impossible for the U.S. to compete globally. *See* Appendix B, Map 1. This not just risks U.S. safety, but the longevity of U.S.-built nuclear safety and proliferation standards.

Russia has more than 50 reactors either under construction, planned, or proposed in 19 countries. Russia has stated that its book of business for nuclear construction projects is well over $130 billion.[72] Russia further estimates 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 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.[73] China has 49 operable nuclear reactors and 16 currently under construction.[74]

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. 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.[75]

In addition, Russia and China are developing nuclear powered ice breakers for use in the arctic, an area of growing strategic importance for great power competition. Just recently, China closed its bidding process that solicited interest for a 152-meter, 33,069-ton nuclear-powered

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

[73] *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/.

[74] World Nuclear, *Nuclear energy in China* (Jan. 2021), available at https://www.world-nuclear.org/information-library/country-profiles/countries-a-f/china-nuclear-power.aspx. By way of background, China introduced its Belt and Road Initiative ("BRI") in 2013. Through the BRI, China initially sought to connect to the rest of Asia, as well as Africa and Europe, via land and maritime networks with the aim of spurring economic growth through interconnectivity. However, since its inception, BRI has now spanned to all regions of the world.1 The BRI is the largest ever global infrastructure undertaking. Under the BRI, Chinese banks and companies have provided billions of dollars for funding to build roads, power plants, railways, ports, and telecommunications infrastructure in dozens of countries. The objectives of BRI focus on establishing and building linkages between China and the rest of the world in the following five areas: (1) enhanced policy coordination; (2) improved infrastructure connectivity; (3) reinforced trade and investment cooperation; (4) financial integration; and (5) supporting people-to people collaboration. But the BRI efforts are not without consequences to both the host country and the United States. A recent Council on Foreign Relations Task Force report examining China's BRI finds "that BRI worryingly adds to countries' debt burdens, locks countries into carbon-intensive futures, tilts the playing field in major markets toward Chinese companies, and draws countries into tighter economic and political relationships with Beijing." Council on Foreign Relations, *Independent Task Force Report No. 79, China's Belt and Road, Implications for the United States*, updated Mar. 2021, at vii available at https://www.cfr.org/report/chinas-belt-and-road-implications-for-the-united-states/. The CFR Task Force concludes that "the risks for both the United States and host countries raised by BRI's implementation considerably outweigh its benefits." *Id.*

[75] 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.

vessel.[76] Also Russia has 38 reactors in operation and 2 under construction domestically, and has stated that its book of business for nuclear construction projects is well over $130 billion.[77] It developed the first modern floating SMR technology,[78] 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, in particular, 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.[79] *See* Appendix B, Map 2 for global advanced reactor developments.

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 energy exports as an important economic opportunity. Nonetheless, lower-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. 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, potentially threatening U.S. peace and security.

For example, Egypt and Russia recently finalized a $21 billion contract for the Russians to supply four reactors in Egypt.[80] 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.[81]

In fact, our core strategic allies—i.e., Japan, United Kingdom, and Korea—are also our main strategic nuclear generation partners. Other alliances that are less mature, such as that with the United Arab Emirates, have been solidified through more recent nuclear cooperation

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[76] 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.

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

[78] World Nuclear News, Russia connects floating plant to grid (Dec. 2019), available at https://world-nuclear-news.org/Articles/Russia-connects-floating-plant-to-grid.

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

[80] *See* Al-Masry Al-Youm, Egypt Independent, *Construction of First Nuclear Reactor at Dabaa Station to Start after Christmas Holidays* (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.

[81] *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.")

agreements.[82] Many key U.S. allies and areas of geostrategic importance lack domestic energy reserves and are highly dependent on foreign energy imports making them dependent on other countries to support their energy needs. Nuclear energy plants provided by the U.S. can reduce our allies' dependence on potentially unstable energy sources, and deepen U.S. ties. And in the same vein, nuclear energy plants provided by our strategic competitors can harm long-term U.S. ties.

But there is opportunity still to turn things around. Around 30 countries across the Middle East, Africa, Central and South America, Europe, and Southeast Asia are considering or beginning new nuclear energy programs—each of which is an opportunity for the U.S. to regain a foothold in the global market.[83] In Europe Hungary and Poland are planning to site new nuclear reactors to replace retired energy systems.[84] A United Kingdom government whitepaper sets forth the Prime Minister's plan to tackle climate change and includes both large and small scale nuclear.[85]

With this incredible expanse of nuclear globally, U.S. innovation in nuclear energy can stand up to state backed competitors. We saw this in the aerospace market when Russia ceded control of the global commercial launch industry, a $5.5 billion market.[86] In 2013, Russia controlled about half of the launch industry with its fleet of launch vehicles, including rockets and Proton boosters. It is now estimated to capture only 10% of the market, due in part to competition from SpaceX.[87]

Continued U.S. presence in the global nuclear market is not good just for U.S. jobs and politics. It is also critically important to ensure that the most stringent safety and nonproliferation standards are exercised. While 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, strong nonproliferation standards are critical to developing the nuclear industry.[88] Developing and spreading U.S. nuclear technology will help ensure high standards for safety and nonproliferation globally.[89] The U.S. has historically used its technological leadership in nuclear energy to promote its geopolitics interests and nonproliferation objectives worldwide. This started with President Eisenhower's "Atoms or Peace" speech in 1954 and continued with the negotiation

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[82] 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.
[83] 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.
[84] 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.
[85] 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.
[86] 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/)
[87] *Id.*
[88] Press Conference, President John F. Kennedy, President's News Conference (Mar. 21, 1963), available at https://perma.cc/B7LW-7WYR); Nuclear Weapons Programs Worldwide: An Historical Overview, INST. FOR SCI. & INT'LSECURITY, available at https://perma.cc/3XQV-P7LY.
[89] 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 energy in Russia* (last updated Aug. 2021), available at https://www.world-nuclear.org/information-library/country-profiles/countries-o-s/russia-nuclear-power.aspx.

of the Non-Proliferation Treaty (NPT) in 1968—where the world's nuclear powers agreed to share civilian nuclear technology with non-nuclear states who agreed to forego nuclear weapons. The U.S. has required each country with whom it has worked to sign and enforce 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 energy Operations); and set forth a global fuel supply framework that reduces risk of proliferation (e.g., 2007 U.S. Assured Fuel Supply Program).

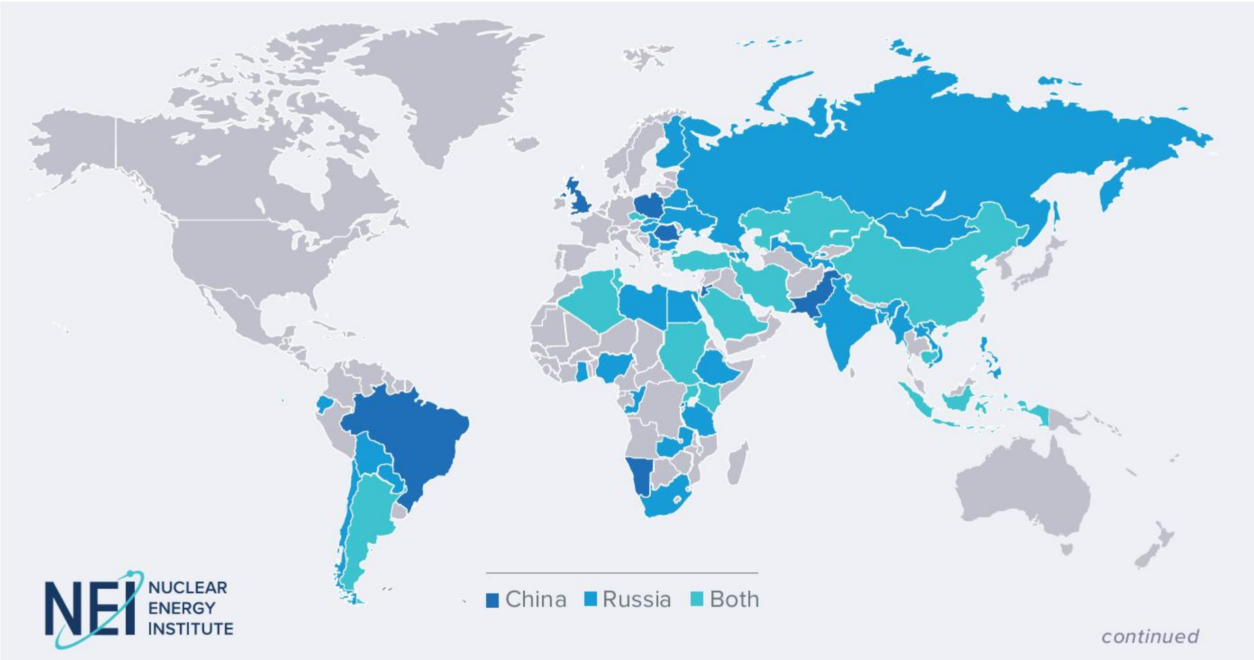
The importance of DOE-NE is advancing the development of advanced reactors and enabling their success in both the U.S. and abroad cannot be understated.

IV. CONCLUSION

Thank you for the opportunity to testify before the Subcommittees on the importance of nuclear energy in our current and future energy structure, and the key role that DOE-NE plays in driving this success. This is a pivotal time for the U.S. energy transition 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.

Appendix A

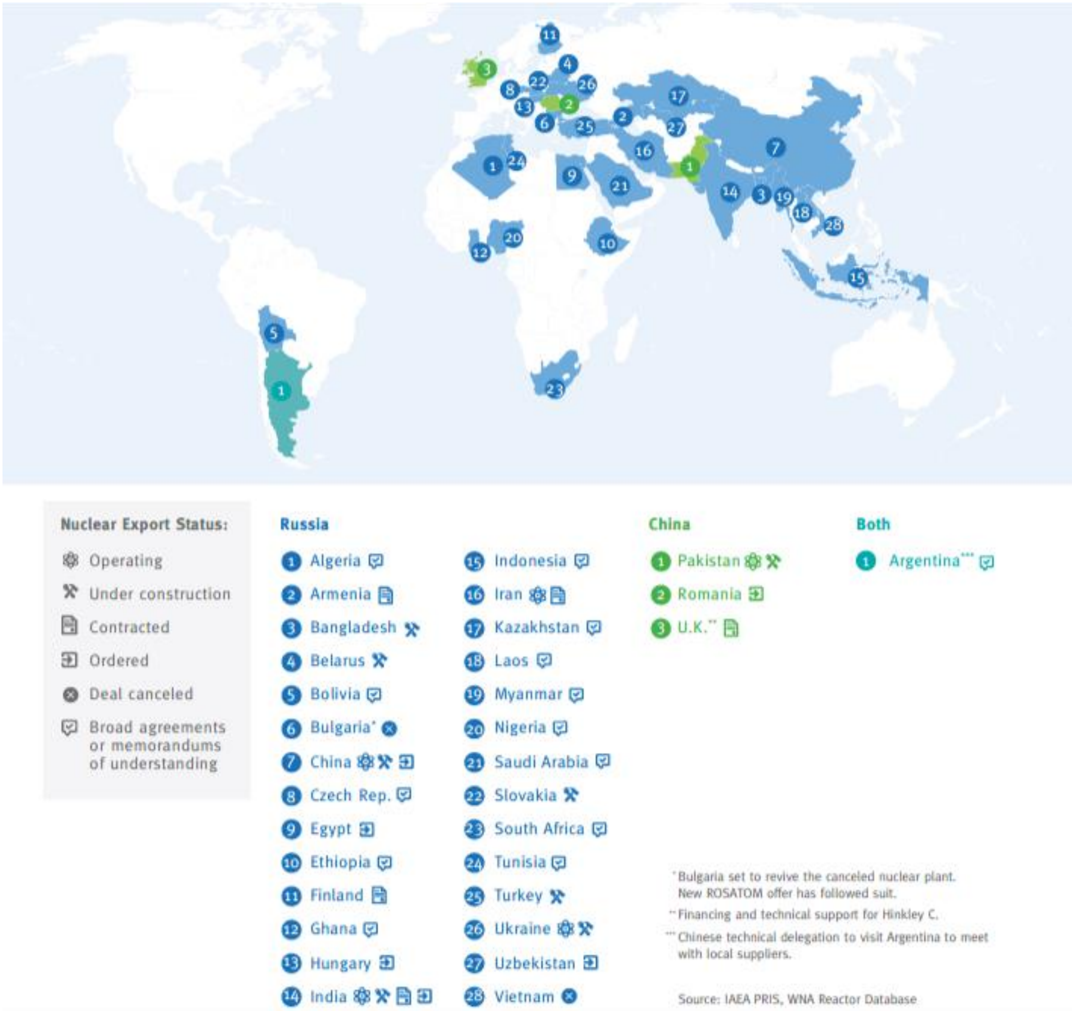
Map 1. Russia and China Global Presence



Source: Nuclear Energy Institute, 2020[90]

[90] 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

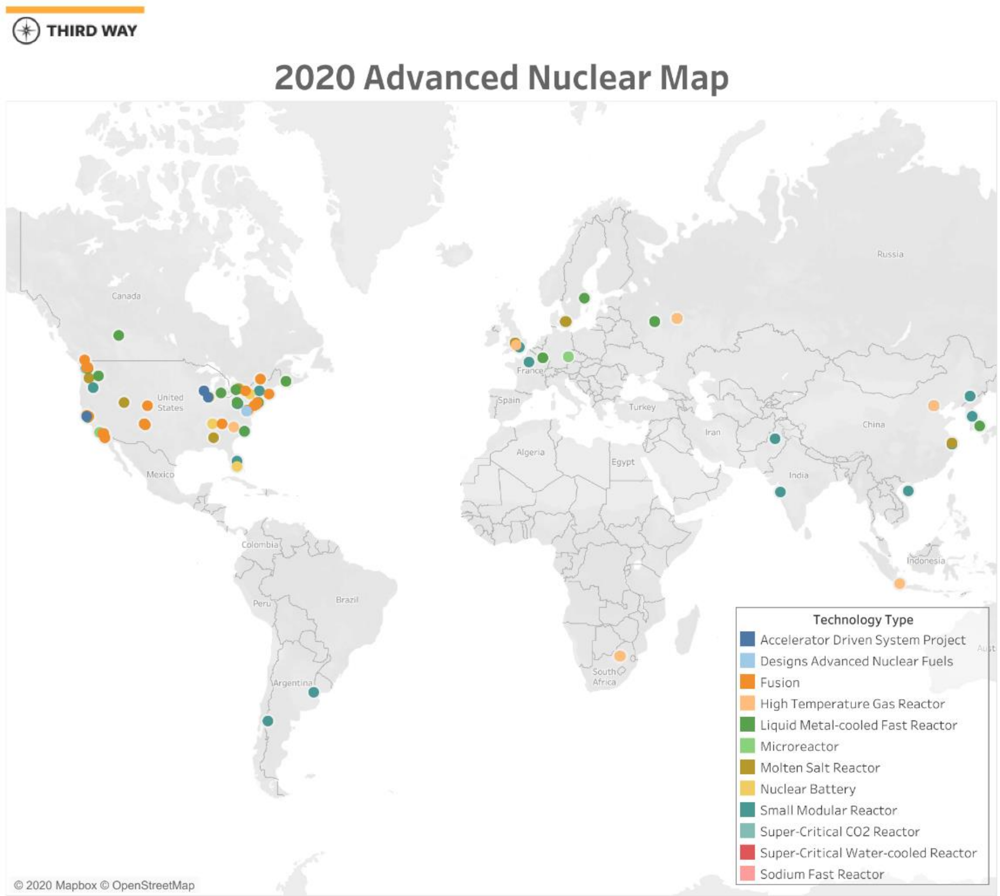


Source: Global Nexus Initiative, 2019[91]

[91] 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.[92]

[92] 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.