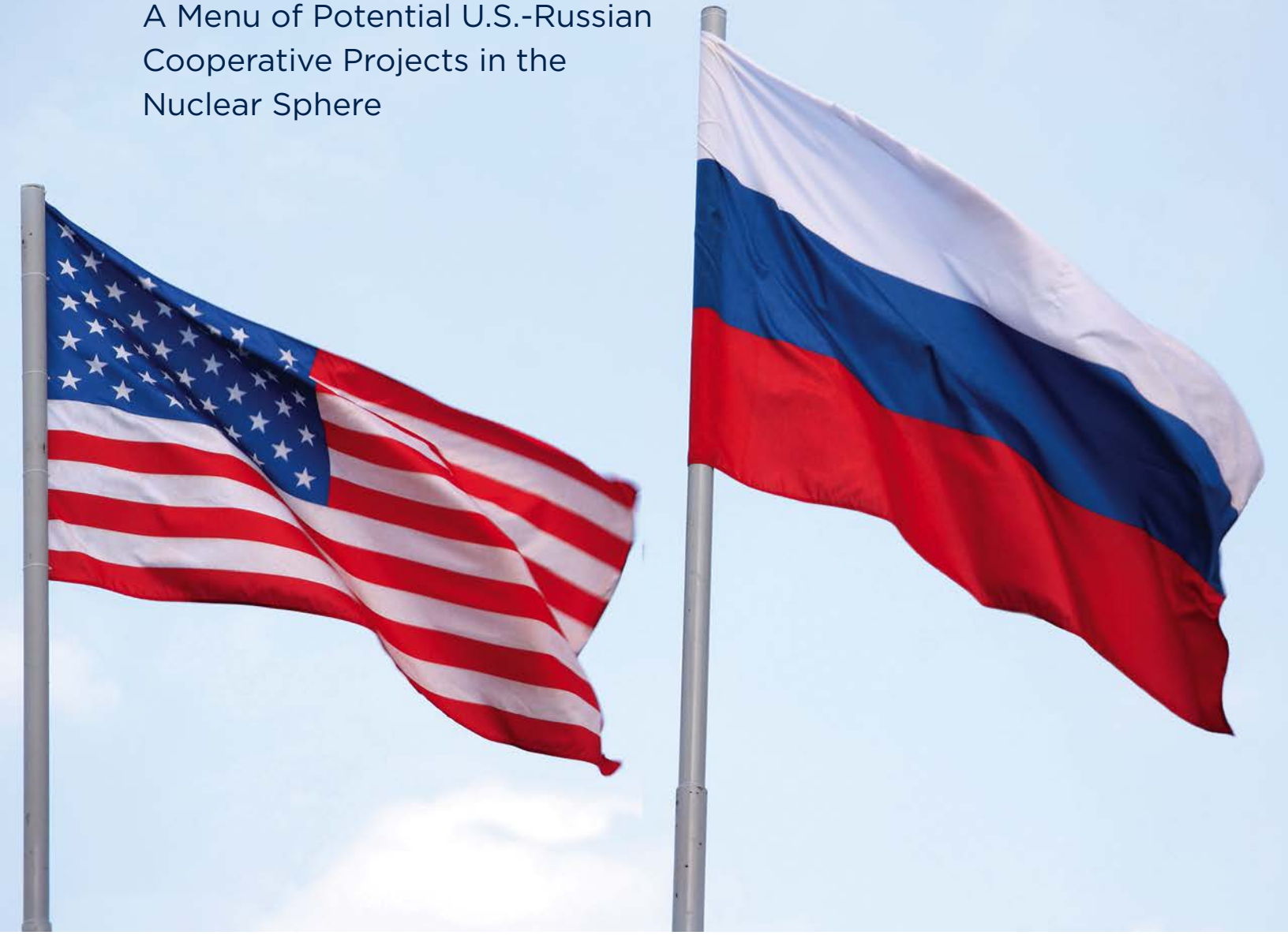
February 2017

Pathways to Cooperation

A Menu of Potential U.S.-Russian Cooperative Projects in the Nuclear Sphere



NTI
BUILDING A SAFER WORLD

Center for Energy and Security Studies
www.ceness-russia.org

Photo Credits

Russian and American flags, © iStockphoto, cover

Sam Nunn and Igor Ivanov, courtesy of NTI, page 2

Artists Concept of an Atom, © Adobe Stock, page 6

Nuclear Power Plant, courtesy of Physics Frontline, page 10

Fukushima Daiichi Power Plant, courtesy of Cryptome, page 14

IAEA Headquarters, courtesy of IAEA, page 17

Savannah River Site Heavy Water Components Test Reactor, courtesy of U.S. Department of Energy, page 21

Steel Framework, © iStockphoto, page 25

Contents

Sam Nunn

Igor Ivanov

Foreword

The United States and Russia today face no shortage of disagreements. From Syria to Ukraine, the differences are serious and stark, but they should not obscure another important truth—that the United States and Russia have mutual, converging interests on some of the most consequential issues of today. Among them is the shared responsibility to manage the destructive forces of the atom while directing those same forces toward positive applications, such as combating climate change.

Today's world is one in which nation-states no longer have a monopoly on the means for mass destruction. Terrorist organizations, such as Daesh (also known as ISIS or ISIL) and al Qaeda, have openly declared their intention to acquire nuclear and radiological weapons. The know-how for developing such weapons is more than 70 years old, and the materials needed to produce them are still stored in too many places and are accessible to too many people. Today, the danger of nuclear terrorism is real, serious, and growing.

These dangers compel collaboration between the United States and Russia, cooperation that unfortunately has almost come to a standstill. Communication between scientists and technical experts in U.S. and Russian nuclear complexes—which dates back to the 1980s—has been frozen. Bilateral forums, such as the U.S.-Russian Nuclear Energy and Nuclear Security Working Group, have been suspended. Differences, including those over Ukraine and the Middle East, have overshadowed nuclear cooperation, putting citizens of both of these nations at greater risk.

This report—developed jointly by the U.S.-based Nuclear Threat Initiative (NTI) and the Russia-based Center for Energy and Security Studies (CENESS)—offers an alternative to the acrimony that has recently characterized these nations' bilateral relations. Building on the success of bilateral cooperation to destroy Syria's chemical weapons stockpile and cooperation to negotiate and begin implementation of the Iran nuclear agreement, this report offers policymakers a menu of dozens of projects on nuclear security and safety issues that could be implemented in the near term and as political relations improve.

The benefits of cooperation can be significant for the United States and Russia and for the world. Together, the United States and Russia could drive critical advancements: (a) developing the next generation of safe and reliable nuclear reactors, (b) investigating novel solutions to common nuclear waste challenges, (c) creating proliferation-resistant nuclear fuels, (d) bolstering the capabilities of essential radiation detectors, (e) improving the safety of commercial nuclear power plants, and (f) interdicting illicit nuclear trafficking in dangerous parts of the world.

Moving forward with projects such as those proposed in this report would also allow the United States and Russia to begin to rebuild the trust critical to putting bilateral relations back on track. If they do not change direction and the acrimony continues to build, these two nations will continue down an increasingly dangerous path and will have missed a crucial opportunity to cooperate on a wide range of urgent nuclear issues.

Sam Nunn
Co-Chairman and CEO
Nuclear Threat Initiative
Former U.S. Senator

Igor Ivanov
President
Russian International Affairs Council
Former Foreign Minister of the
Russian Federation

Introduction

By Andrew Bieniawski, Vice President, NTI
Anton Khlopkov, Director, CENESS

In February 2016, dozens of leading nuclear experts from the United States and the Russian Federation gathered in Moscow for a conference on the potential for future nuclear cooperation between the world's two largest nuclear powers. The dialogue—cosponsored by the Nuclear Threat Initiative (NTI) and the Center for Energy and Security Studies (CENESS)—was the first of its kind in many years, bringing together experts from industry, think tanks, academia, and non-governmental and governmental institutions.

The conference was preceded and supported by preparatory research efforts, including separate working meetings of U.S. and Russian experts to develop proposals that would reflect each country's interest to the fullest extent possible. A list of the experts, along with the conference participants, can be found can be found on page 30.

The result of the NTI-CENESS Dialogue on Potential U.S.-Russia Nuclear Cooperation is a menu of possible projects designed to use the countries' unique technical capabilities to advance their mutual interests. Conference attendees discussed the potential for cooperation on nuclear issues across five areas:

- Nuclear science
- Nuclear energy
- Nuclear safety
- Nuclear security
- Nuclear environmental remediation

The experts reviewed a list of proposed projects[1] designed to advance key objectives for both countries across all five thematic areas. This list is not meant to be exhaustive but rather illustrative of the universe of prospective collaboration between the United States and Russia in the nuclear sphere. Some critical projects could proceed now; others will require more time as political relations improve and as trust is restored.

The following projects were proposed:

On nuclear science, expanding research on the effects of radiation, developing advanced radiation detection equipment, and using the two countries' state-of-the-art research facilities to develop new materials for nuclear applications

On nuclear energy, jointly developing innovative reactor designs, collaborating across the fuel cycle, and promoting safety and security in nuclear newcomer countries, including through education and training programs

On nuclear safety, collaborating to standardize reactor designs, to harmonize reactor licensing approaches, to improve regulator-to-regulator cooperation, to strengthen international safety incident

[1] The projects offered in this report were compiled from U.S. and Russian proposals by the co-chairs of the 2016 NTI-CENESS Dialogue on Potential U.S.-Russia Nuclear Cooperation in Moscow: Andrew Bieniawski (NTI) and Anton Khlopkov (CENESS). This compilation of possible projects does not necessarily reflect the views of individual participants at the conference.

response and management, and to ensure the safety of next-generation nuclear technologies

On nuclear security, developing joint projects to secure potentially dangerous radioactive sources and nuclear materials in Central Asia, to prevent illicit trafficking of nuclear and radioactive materials, to improve nuclear security education and training resources, and to expand nuclear security technical cooperation with other countries

On nuclear environmental remediation, advancing cooperative approaches—such as decommissioning nuclear facilities, including those in third countries—and innovative research and development (R&D) on technologies and processes to remediate contaminated soil and groundwater

In addition to the proposals, four broad themes emerged from the project.

First, nuclear cooperation should not be held hostage to oscillations in U.S.-Russian political relations. The United States and Russia share common interests, opportunities, and challenges on nuclear and scientific issues that do not change with political swings. If a terrorist detonates a nuclear bomb in any major city or a nuclear accident occurs, the consequences will be immediate and will remain for generations. Many U.S.-Russian nuclear challenges are global and enduring, and it is in neither nation's interest to impose political costs on the other by withholding technical cooperation that benefits each country and the world. In the event of a terrorist attack or nuclear accident, the United States and Russia will need to rely on each other. That is among the reasons cooperation on nuclear issues is so important—even during times of serious disagreements on other matters.

Second, scientific engagement can be the engine for innovation in nuclear cooperation and can provide a basis for rebuilding trust between these two countries. Scientific collaboration between the United States and Russia dates back centuries and continued through the Cold War, and there remains broad, unrealized potential for cooperation between each country's respective scientific communities. Yet this potential today is constrained by political barriers that prevent collaboration between technical experts working in the U.S. and Russian nuclear sectors. Despite these barriers, experts should engage with one another to advance technical understanding and to expand the boundaries of science for the mutual benefit of the U.S. and Russian populations.

Third, nuclear cooperation should be premised on the principle of mutual benefit. Both the United States and Russia have unique and sophisticated facilities, technologies, expertise, and experience, and they complement each other. Future projects should be designed to leverage the capabilities of both nations to their mutual benefit.

Fourth, the United States and Russia have a special imperative to work together to address the threat of nuclear terrorism. As leading nuclear exporters with nearly 90 percent of the world's nuclear materials, the United States and Russia bear a special responsibility to ensure that dangerous nuclear materials and radioactive sources (the key ingredients for a "dirty bomb") never end up in the wrong hands. Given the growing capabilities and declared objectives of terrorist organizations, more work needs to be done across multiple levels—political, technical, and intelligence—to prevent these groups from acquiring the means to carry out acts of nuclear or radiological terror.

It is now incumbent on key stakeholders from both governments to determine how best to advance these initiatives. As described earlier, the projects listed in the following pages are recommendations for prospective cooperation, recognizing that they will not all be possible to implement immediately. Over time, however, as trust is rebuilt and cooperation improves, there is hope that the governments of the United States and Russia will be able to realize more of these initiatives for the benefit of their citizens and the world.

NUCLEAR SCIENCE

The United States and Russia have a rich history of collaboration in science.

In 1789, U.S. statesman and scientist Benjamin Franklin invited Ekaterina Dashkova to become the first woman member of the American Philosophical Society. The same year, the Duchess Dashkova helped secure Franklin's appointment to the St. Petersburg Academy of Sciences, the forerunner of the Russian Academy of Sciences. Since then, the United States and Russia have pursued many great achievements together, including the development of the live polio vaccine and the first international space partnership, the Apollo-Soyuz Test Project.

Even during the Cold War, Moscow and Washington found common ground. For example, in the sphere of nuclear science, Russia and the United States collaborated formally for several decades on such projects as the Soviet-American Gallium Experiment of the 1980s. Cooperation advanced in 1991, owing to the mutual understanding of the benefits of bilateral engagement between two of the world's leading scientific communities. This cooperation paved the way for the first U.S.-Russian "lab-to-lab" exchanges, which allowed U.S. and Russian nuclear scientists to meet their

Going forward, it is essential that both governments "do no harm" to the foundation of scientific collaboration that exists between the United States and Russia.

counterparts for the first time. The relationships developed between these constituencies proved invaluable, as scientists from technical institutes and laboratories partnered to address immense safety, security, and scientific challenges.

In recent years, however, U.S. and Russian collaboration in nuclear science has stalled because of the downturn in bilateral political relations. Many scientists now face restrictions on travel to each other's countries to conduct scientific research. This development endangers more than three decades of collaboration in nuclear science and threatens a generation of cooperative research endeavors.

Going forward, it is essential that both governments "do no harm" to the foundation of scientific collaboration that exists between the United States and Russia. Scientific endeavors—pursued for the common good—should not fall victim to the frequent oscillations in bilateral relations.

Prospective bilateral and multilateral projects for nuclear science could include the following:

- **Establish a joint working group to identify projects for U.S.-Russian cooperation as part of an international research venture based at the Multipurpose Fast Research Reactor (MFRR).** The MFRR is a unique research facility being constructed at the Research Institute of Atomic Reactors (RIAR) in Dimitrovgrad with the capability to expose materials to high-intensity neutron flux. This facility could prove valuable for future bilateral research in advanced fuels, materials, simulations, transmutation, and fundamental sciences. Investigations in these spheres will support research on (a) promoting efficient consumption of nuclear fuels, (b) resolving technical barriers associated with spent nuclear fuel and radioactive waste processing, (c) validating safe operation of nuclear fuels and components, and (d) reducing the risks of nuclear proliferation.
- **Pursue cooperative research on radiation damage and nuclear materials for reactor applications.** The United States and Russia have distinct facilities and capabilities that can complement each other's research efforts. Certain advanced reactor designs, such as lead-cooled fast reactors, require extensive testing to design and validate materials that can withstand the harsh operating conditions inside the reactor. Both countries have unique neutron sources, such as the Multipurpose Fast Research Reactor in Russia and the Spallation Neutron Source in the United States. Together, these laboratories can leverage their cooperation to develop better materials for nuclear applications, such as radiation-resistant metals and ceramics. In addition, academic institutions in both countries can cooperate to conduct joint experiments at these facilities.

Research Institute of Atomic Reactors (NIIAR), Dimitrovgrad, Ulyanovsk Oblast, Russia

SOURCE: Rosatom State Corporation Enterprise

Oak Ridge National Laboratory, Oak Ridge, Tennessee, United States

SOURCE: Oak Ridge National Laboratory, U.S. Department of Energy

- **Establish cooperation on actinide chemistry and metallurgy to support work on advanced nuclear fuels and fuel cycles.** Both the United States and Russia are actively designing advanced nuclear fuels but with very different research facilities and experiences. In addition, both countries have pursued lead-cooled and transmuting fast reactor designs at some point, but research in designing appropriate fuel meats is not yet mature enough for demonstration and deployment. Both countries stand to benefit from a bilateral project that shares prior experiences and unique approaches to fuel and fuel cycle research.
- **Pursue more extensive collaboration on experiments in underground science and ultralow background measurements.** The United States and Russia have a history of cooperation in this field because of their collaboration on the joint Soviet-American Gallium Experiment. The next generation of experiments investigating solar neutrino flux will benefit from facilities and capabilities unique to both the United States and Russia. Russia has extensive capacity for enrichment of stable isotopes used for international experiments in nuclear science and provided the liquid xenon used at the Enriched Xenon Observatory in New Mexico. The next generation of experiments will require even more extensive U.S.-Russian cooperation, owing to the fact that increasingly sensitive experiments will require larger amounts of isotopically pure xenon.
- **Pursue parallel (and eventually joint) analytical chemistry and radiochemistry exercises to improve methodologies and to support nuclear forensics and nuclear nonproliferation safeguards.** Before the deterioration of U.S.-Russian relations, bilateral analyses of nuclear samples were planned between U.S. national laboratories and their Russian counterparts. These analyses are generally conducted against established standards. Different countries and sometimes different laboratories within countries use different standards. As a result, the United States and Russia have compiled distinct but complementary data sets. Exchanges of best practices and nuclear samples would be valuable to global nuclear forensics and nonproliferation stakeholders, including the International Technical Working Group on Nuclear Forensics, the International Atomic Energy Agency (IAEA), and both the United States and Russia. A research organization in a third country, such as the Institute for Transuranium Elements in Karlsruhe, Germany, could also provide

reference materials. These initial data-sharing efforts could serve as a foundation for a broader array of joint or simultaneous analyses of samples and could lay the groundwork for the two countries to establish a nuclear forensics technical working group to develop and routinely exercise procedures for addressing technical issues, including sample and data exchange and analysis.

- **Conduct joint experiments to determine the cross-sections of high-energy neutrons' interactions with various materials.** Modeling processes that take place inside nuclear reactors requires detailed knowledge of cross-sections of various reactions and fission yields and of half-lives of short-lived radionuclides, but some of these data are highly uncertain because of the state of the art when nuclear-data campaigns were undertaken decades ago. Both the United States and Russia will gain by collaborating to improve the quality and sophistication of data inputs to their computer models. Such collaboration will enable accurate modeling of myriad processes, such as those taking place inside fast neutron reactors in order to develop novel nuclear fuels, or those taking place in improvised nuclear devices to advance nuclear forensics capabilities.

- **Reinvigorate cooperative research on nuclear data measurements.** Fundamental physical characteristics of certain nuclear data—such as half-lives, neutron cross-sections, and fission yields—are often highly uncertain because of the state of the art when research campaigns were undertaken decades ago. These measurements are not inherently sensitive from a security perspective, and both the United States and Russia have incomplete data on certain species that may complement each other.

- **Pursue joint development of technology and hardware for monitoring shipments of nuclear and radioactive materials.** The United States and Russia have independently developed various technologies and databases to monitor the shipments of nuclear and radioactive materials to ensure the safety and security of shipments and to counter nuclear smuggling, including during legal shipments. Collaboration in this field will leverage both countries' expertise in monitoring transportation of nuclear and radioactive materials.

- **Cooperate on lower-cost, more compact, and higher-resolution radiation detector systems for countering nuclear smuggling.** U.S. and Russian researchers have explored different materials and approaches for detection that may complement each other in advanced detector technologies. Future research may focus on developing (a) improved detection capabilities; (b) alternative technologies to helium-3-based detectors; and (c) active particle interrogation techniques for detection of shielded materials, a challenge common to radiation detectors in both countries.

- **Strengthen engagement under the Nuclear Safety Research working group of the Organisation for Economic Co-operation and Development's (OECD) Nuclear Energy Agency (NEA) and increase cooperation on a prioritized nuclear safety research agenda.** Both Russia and the United States participate in the OECD NEA's Nuclear Safety Research working group, which uses facilities around the world. But existing work could be augmented by the world's two largest nuclear powers by projects conducted in the United States and Russia. In particular, both countries have made specific contributions in advanced modeling and simulation capabilities in the field of nuclear safety that can complement each other's independent efforts.

- **Support cooperative research on radioactive waste in underground tanks and on waste forms.** Owing to their nuclear legacies, both Russia and the United States have substantial radioactive waste caches stored in underground tanks. Managing the integrity and minimizing the environmental impacts of these tanks are a complex and expensive endeavor. Russia and the United States have taken different approaches in R&D of advanced waste technologies, and their shared environmental experiences would provide substantial value to both nations' stewardship of radioactive waste.

NUCLEAR ENERGY

Addressing climate change will require the safe and secure use of nuclear energy.

Nuclear power plants affordably and reliably provide more than 11 percent of electricity globally. Given projected 21st-century energy requirements, expanding the supply of base-load power delivered by nuclear energy will be essential to meeting surging demand. In addition, nuclear energy is a crucial part of the answer to the global challenge of climate change, as it is one of the proven energy sources already deployed on a large scale and one that produces negligible greenhouse gas emissions.

The U.S. and Russian nuclear establishments are among the world's largest. They are market leaders for reactors, fuels, and materials, and they are at the forefront of efforts to develop the next generation of nuclear technologies. Enhanced bilateral nuclear cooperation can produce mutually beneficial outcomes by (a) expanding commercial nuclear energy, (b) reducing the cost of nuclear power, (c) increasing industry profits, and (d) generating higher standards of safety and security around the world.

Enhanced bilateral nuclear cooperation can produce mutually beneficial outcomes by expanding commercial nuclear energy, reducing the cost of nuclear power, increasing industry profits, and generating higher standards of safety and security around the world.

Prospective bilateral and multilateral projects for nuclear energy could include the following:

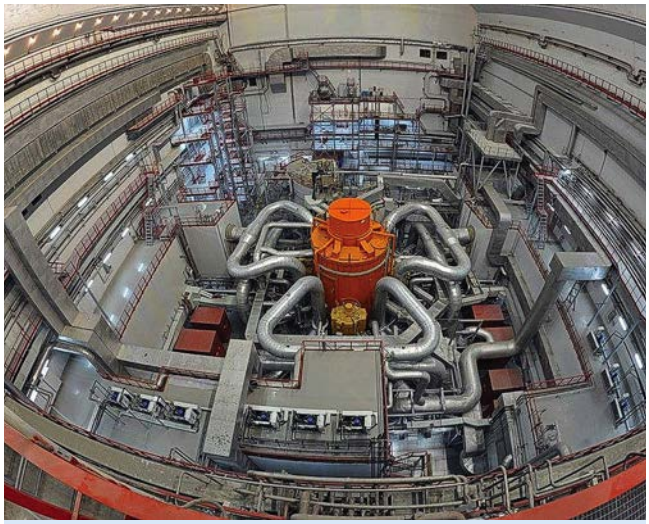
- **Establish a joint working group to study, develop, and demonstrate future generations of nuclear reactors.** Innovative technologies can reduce energy costs, reduce up-front investment costs, increase safety, and increase proliferation resistance. Technical experts can collaborate on a host of reactor concepts and designs, including small modular reactors and fast reactors. In particular, several existing research groups should be formalized and coordinated to focus on challenges for Generation IV lead-cooled fast reactors, in particular materials that are resistant to corrosion, temperature, and radiation. Future cooperation can also include joint development of novel fuels, such as high-density and metallic fuels (with applications for both fast and research reactors).
- **Develop accident-tolerant fuels.** The disaster at Fukushima in 2011 vividly illustrated the urgency of developing fuels that will maintain integrity longer and better than standard uranium dioxide–zirconium fuels in the case of a loss-of-coolant accident. The United States and Russia should initiate technical collaboration on accident-tolerant fuels within the international framework of the IAEA Technical Working Group on Nuclear Fuel Cycle Options and Spent Fuel Management.
- **Collaborate on bilateral ventures across the fuel cycle to promote safe, secure, and reliable nuclear power development.** A host of bilateral projects would be beneficial to both U.S. and Russian nuclear industries, including reciprocal access to (a) supply chains (incorporating U.S. equipment—instrumentation, control systems, and generators—into Russian-designed reactors); (b) fuel fabrication research, development, and demonstration (RD&D); and (c) policies and practices that will help increase the depth of fabrication supply sources, fuel bundling, and cradle-to-grave fuel services (incorporating Russian fuel cycle capabilities), as well as coordination on procurement, quality assurance, and liability standards. In the management of used fuel and high-level waste, opportunities for collaboration include technical work on waste forms, research on the economics of interim storage and final disposal, dry cask storage technology, and underground research laboratory RD&D to address such challenges as repository design and deep borehole disposal.
- **Cooperate in third countries across the fuel cycle to ensure the safe operation of nuclear power plants, to advance nonproliferation objectives, and to promote reliable, cost-effective nuclear energy.** Many topics discussed above can also be pursued collaboratively in third-country markets, including fuel bundling, cradle-to-grave services, procurement coordination, quality assurance, common international liability

standards, and management of used fuel and high-level waste. The United States and Russia should also consider exploring low-cost financing options for—and the political and economic benefits of—taking back used fuel and high-level waste from these markets.

- **Cooperate on transportation of used fuel and high-level waste.** Transportation of used fuel and high-level waste has an outstanding safety record. However, there is always more work that U.S. and Russian experts can do to improve safety and security of used fuel and high-level waste in transit. In particular, some technical challenges are ripe for collaboration, including package design (i.e., packages that can accommodate multiple fuel types) and safety analyses (e.g., package performance in long-duration fires).

- **Establish joint exchange programs for students and young professionals.** Given the long realization time of nuclear energy projects and concerns over the aging of the nuclear workforce, connections made between younger generations now will have positive results in the future. The United States and Russia should promote technical discussions and exchanges between early-career nuclear engineers to develop the next generation of technical experts. Organizations such as the World Association of Nuclear Operators (WANO) and the Institute of Nuclear Power Operations represent a starting point, as both support Young Generation in Nuclear chapters in the United States and internationally. Other promising forums include major conferences (e.g., Atomexpo and the American Nuclear Society Conference); research exchanges; and student activities, such as the summer camp Forsage in Russia.

- **Provide educational and training support for nuclear infrastructure development in nuclear newcomer countries.** Thirty countries are currently actively considering launching their own nuclear energy programs, and Russia and the United States have each secured supply agreements with many of these newcomer countries. Various educational and training projects are already under way to assist newcomers, but better coordination between U.S. and Russian programs will increase the efficiency of related efforts. Focusing on and conducting exchanges with early-career engineers can help train and develop the next generation of technical experts. Programs that are jointly developed and taught and that target technical employees and mid- and top-level management can include classroom courses (including distance education), practical exercises, and site visits. Teaching modules could include (a) building safety culture, (b) conducting effective project management, (c) nurturing workforce development (e.g., craft labor), and (d) establishing robust regulatory structures. As a first step, U.S. and Russian industry representatives, together with the IAEA, should assess existing programs to identify and prioritize gaps.



BN-800 Fast Breeder Reactor, Beloyarsk Nuclear Power Station, Zarechny, Sverdlovsk Oblast, Russia

SOURCE: Rosatom State Corporation Enterprise

- **Engage in dialogue on using nuclear energy for purposes other than electricity generation.** Expanding the mission of nuclear reactors and technologies to play a larger role in meeting future energy needs presents an opportunity for significant cooperation. This expanded role includes such activities as (a) desalination, (b) hydrogen production, (c) oil recovery from tar sands and oil shale, (d) medicine, and (e) food preservation. In addition, future spaceflight missions may require novel nuclear technologies to

Daniel Poneman, former Deputy Secretary of Energy, United States speaking at the NTI-CENESS Dialogue

SOURCE: NTI, NTI-CENESS Dialogue on the Future of U.S.-Russia Nuclear Cooperation

Nikolay Spasskiy, Deputy Director-General, Rosatom, Russian Federation speaking at the NTI-CENESS Dialogue

SOURCE: NTI, NTI-CENESS Dialogue on the Future of U.S.-Russia Nuclear Cooperation

power advanced propulsion and life-support systems. There may be opportunities for joint U.S.-Russian R&D ventures across these applications.

- **Continue efforts to establish low-enriched uranium alternatives for medical isotope production.** The United States and Russia should continue laying the groundwork for a smooth transition to production of molybdenum-99 (Mo-99) without the use of highly enriched uranium (HEU). In addition, U.S. and Russian industry partners should coordinate strategies and investments to avoid market interruptions from conversion activities. Both the United States and Russia can also further accelerate adoption of non-HEU-based Mo-99 by assisting in the regulatory approval processes, including in third countries.
- **Establish a joint working group on fuel cycle market analysis and projections.** A U.S.-Russian government and industry working group should be created to periodically review high-quality market projections—from access to uranium resources (including advanced uranium recovery technologies and cost recovery from unconventional resources) to demand for enrichment and reprocessing services—produced by organizations such as the World Nuclear Association, Euratom Supply Agency, and IAEA. Such collaboration will help reduce bottlenecks, enhance supply chain reliability in the short term, and improve long-range energy policy and RD&D planning.
- **Collaborate to ensure sustainable development of nuclear energy.** To ensure sustainable development of nuclear energy in the long term, Russia and the United States should collaborate on R&D pertaining to novel proliferation-resistant fuel technologies that would increase the pool of resources (fuel) available for the nuclear energy industry. Such cooperation might also create additional pathways to implement the Plutonium Management and Disposition Agreement.[2]

[2] Cooperation under this Agreement has been suspended but could be resumed at a later date.

NUCLEAR SAFETY

Preventing nuclear accidents requires close collaboration on nuclear safety.

More than three decades have passed since the tragic accidents at the Three Mile Island and Chernobyl nuclear power plants focused global attention on the importance of nuclear safety. Those accidents catalyzed important regulatory reforms and design modifications, but the catastrophe at Fukushima Daiichi in 2011 demonstrated that more work must be done to improve nuclear safety worldwide.

As two of the world's leaders in nuclear energy, the United States and Russia should lead the way in global efforts to continuously improve the safety of nuclear reactors and other nuclear operations. The two governments—along with their respective regulatory authorities, industries, and scientific communities—should work bilaterally and with other countries and international institutions to ensure safety in reactor designs and construction; to enhance safety culture; and to improve incident response, communication, and management. This work will also help protect the investments made by the two countries' governments and nuclear industries over the past few decades. As previous accidents and disasters have

demonstrated, a nuclear incident in any of the countries operating nuclear power plants can have a negative impact on global nuclear energy prospects.

Importantly, as additional countries seek to develop civilian nuclear energy programs, there is an imperative to ensure that nuclear newcomer countries have both effective safety operations and safety culture, as well as strong and independent regulatory authorities. Toward that end, the United States and Russia should partner with nuclear newcomer countries to ensure the safe and responsible growth of nuclear energy. That includes (a) creating new platforms for safety training and education, (b) developing regulator-to-regulator relationships, (c) exchanging nuclear safety best practices, and (d) promoting facility-level operational safety excellence.

The United States and Russia should undertake these activities in conjunction with the IAEA, as well as industry-led organizations, such as WANO.

Prospective bilateral and multilateral projects for nuclear safety could include the following:

- **Establish a dialogue on nuclear safety culture.** The United States and Russia both participated in the 2016 IAEA International Conference on Human and Organizational Aspects of Assuring Nuclear Safety and are well situated to discuss identified future needs in nuclear safety culture. A bilateral dialogue could provide a platform to demonstrate tangible follow-on results to present to the international community. This dialogue should include a regular exchange of information on safety culture, enhanced by strong support for the activities of organizations focused on nuclear safety—such as WANO and the Institute of Nuclear Power Operations—that will be particularly important in providing nuclear safety reviews before initial power operations at newly constructed nuclear sites.
- **Cooperate on nuclear and radiation safety of advanced nuclear technologies.** The United States and Russia are independently developing advanced nuclear reactors, fuel, and fuel cycles that require significant safety analyses before they can be commercialized. Both countries can benefit from a dialogue on ensuring safety excellence for next-generation nuclear technologies, involving experts from both industry and regulatory authorities.
- **Exchange post-Fukushima regulatory actions.** Both U.S. and Russian nuclear industries were significantly affected by the Fukushima Daiichi accident and could learn from each other's experiences in regulatory reform, consequence mitigation, and emergency response. Regulator-to-regulator communication would also allow both countries to evaluate and compare their mitigation strategies and could also serve as a vehicle to share lessons learned for public information campaigns and community relations. As a first step, a conference involving U.S. and Russian regulators should be organized to share best practices and to discuss actions both countries have taken since the Fukushima accident. The bilateral regulatory arrangement that expired in 2012 should be renewed to facilitate this cooperation. Similarly, improving integration of plant design, construction, and decommissioning can reduce costs and simplify licensing, particularly in such areas as high-cycle thermal fatigue, corrosion and irradiation treatment, and new materials safety.
- **Exchange pertinent data for criticality calculations.** Both the United States and Russia have independently developed libraries of data pertinent to criticality calculations, such as neutron cross-sections for construction materials. Both countries will benefit from a mechanism that shares relevant data for criticality calculations. Such sharing will enhance both countries' models to ensure adequate criticality margins when developing advanced nuclear fuels and reactor components.
- **Exchange severe accident codes and develop new applications for probabilistic risk assessment (PRA).** Previously, the United States and Russia had extensive regulator-to-regulator cooperation on severe accident codes and models, and there are existing relationships between experts that can help restart cooperation in this field. Other parties, such as both countries' national laboratories

As previous accidents and disasters have demonstrated, a nuclear incident in any of the countries operating nuclear power plants can have a negative impact on global nuclear energy prospects.

and industry stakeholders, may be interested in renewed collaboration on severe accident codes. Similarly, building on successful previous experience in implementing PRA for safety analyses, U.S. and Russian experts should implement joint projects to analyze more nuanced scenarios, such as extreme natural event accidents; aircraft impact; and new nuclear reactor concepts. Such joint projects would satisfy a mutual safety need.

- **Cooperate to train the next generation of nuclear safety experts.** Both the United States and Russia have an aging regulatory staff and a diminished pipeline of nuclear safety experts. Both countries can benefit from exchanging lessons learned regarding programs that attract talent to the nuclear safety field. In particular, the governments of the United States and Russia can establish broader collaboration across universities and research institutions to improve educational pathways to nuclear safety professions.
- **Collaborate on reactor standardization and licensing.** There is significant interest in the United States and Russia to streamline the licensing process for new reactor designs in order to reduce costs and expedite construction of new reactors. In addition, both industry and regulators can collaborate to standardize licensing applications and procedures to establish a predictable and consistent method for review and certification.
- **Establish a bilateral standing forum among regulators on nuclear safety.** Representatives from the U.S. Nuclear Regulatory Commission and Rostechnadzor should meet at least once a year to review common safety challenges and best practices. A standing committee could expand on previous and existing dialogue, including reciprocal observation of training exercises and simulations. This bilateral dialogue will complement ongoing multilateral efforts being undertaken by the IAEA.
- **Establish joint technical studies on the extension of power reactor operating lives and reactor license renewals.** If a reactor can continue operating safely at the end of its initial license, it is far more cost-effective to keep it operating than to shut it down and build a new unit to replace it. Of the 100 operating U.S. power reactors, 78 have received 20-year license renewals to operate—for a total of 60 years—from the Nuclear Regulatory Commission. In Russia, 24 of 35 power reactors, generally licensed for an initial 30-year period, have received license renewals that range between 15 and 30 years, depending on reactor type. The United States and Russia should conduct joint studies on the extension of reactor operating lives and reactor license renewals, leveraging new approaches regarding license renewals.

NUCLEAR SECURITY

Cooperation is needed to address evolving threats to our mutual security.

Russia and the United States have the world's largest stocks of weapons-usable nuclear materials and the world's largest nuclear complexes. As the countries with the greatest nuclear security experience, they share a special responsibility for preventing nuclear terrorism. Each country has the knowledge and resources needed to secure its own nuclear stockpiles. Both countries have acknowledged over the years, nuclear security must continuously evolve in the face of changing threats. Both countries can further reduce the risk of nuclear terrorism if Russian and U.S. experts work together to achieve excellence in nuclear security in their own country and to help other countries do the same. Recent events around the world remind us of the need for international cooperation to reduce the risk of nuclear terrorism.

In the past, U.S.-Russian cooperation in this area has accomplished a great deal both by improving nuclear security and by helping eliminate HEU in many other countries. New projects designed to serve national interests in both the United States and Russia should be based on equal partnership and mutual benefit,

Recent events around the world remind us of the need for international cooperation to reduce the risk of nuclear terrorism.

with each country paying its own share of the cooperation.

Another area for prospective cooperation should be security of radioactive sources. Radioactive sources—such as cesium-137, cobalt-60, americium-241, and iridium-192, which can be used to make a "dirty bomb"—are found in thousands of potentially vulnerable locations around the world, including hospitals, universities, and industrial sites. Cooperation to secure or eliminate these sources, particularly with third countries, could help reduce the risks of radiological terrorism.

Prospective bilateral and multilateral projects for nuclear security could include the following:

- **Address security of radioactive sources in Central Asia.** Hundreds of radioactive sources, potential ingredients for a radiological dispersion device ("dirty bomb"), are found across Central Asia in hospitals, universities, industrial sites, and other locations. In collaboration with the governments where these materials are found, U.S. and Russian technical teams could cooperate to secure and/or remove these sources. Moreover, joint activities could be implemented to enhance efforts to close potential nuclear smuggling routes through the Central Asian trafficking corridor, including through deployment of radiation detection equipment, through the training of border and customs officials, and through improved channels of communication between key stakeholders in the region. Such cooperation could be extended beyond Central Asia to include other priority regions, such as the Middle East, North Africa, and South Asia.
- **Establish joint technical-level working groups and best-practice exchanges.** Among the most important initiatives would be to ensure that U.S. and Russian experts working on similar technological and organizational challenges are in regular contact and are sharing ideas on the best approaches to solving them. This initiative could be accomplished by the formation of joint U.S.-Russian working groups in particular technical areas and by both countries' providing the authorization and joint funding needed for them to work together. Exchanges of good practices in these areas could be a key element of such an approach. Each country could choose how best to implement the ideas exchanged or developed in the working groups; in some cases, the working groups might develop joint technical guides or launch joint R&D projects to improve particular technologies. Areas for joint working groups might include (a) material accounting and control for bulk-processing facilities, (b) tamper-indicating devices, (c) vulnerability assessments, and (d) performance testing (including force-on-force exercises, insider threat protection, security culture, and regulation and inspection).

- **Expand nuclear security education and training programs.** University-level education programs and specialist personnel training courses in nuclear security have been a central component of U.S.-Russian bilateral cooperation. Russia and the United States should continue to (a) cooperate in developing new training courses and updating the existing ones; (b) share experience in personnel training, including joint workshops and conferences for university lecturers and instructors of specialized training centers; (c) continue student and teacher exchanges; (d) offer internships and joint student projects; and (e) produce textbooks and training aids.

- **Strengthen nuclear security regulatory cooperation.** Russia's nuclear security regulator, Rostechnadzor, and the U.S. Department of Energy and the U.S. Nuclear Regulatory Commission have a long history of cooperation. However, much of that cooperation has been limited by political circumstances. Further work can be done to bolster regulator-to-regulator cooperation, including through best-practice exchanges on regulatory development, inspection techniques, licensing, and enforcement provisions. Regulator-to-regulator cooperation can be leveraged to enhance both U.S. and Russian nuclear security regimes, to support regulatory development for nuclear newcomer countries, and to deepen partnerships with industrial users of nuclear and radiological materials.

- **Conduct joint R&D on improved nuclear security and accounting technologies.** Additional R&D is needed to provide more effective and cost-efficient technologies and approaches for physical protection, material accounting, material control, and other security applications. A joint nuclear security R&D program should be established with a pool of funding that a committee of Russian and U.S. experts would allocate to the most promising projects. Areas for joint R&D might include (a) improved computer tools for vulnerability assessment; (b) improved technologies for nuclear materials and explosives detection (including in the face of shielding); (c) improved technologies and approaches for measuring the plutonium and uranium content of spent nuclear fuel, of scrap, and of radioactive wastes; (d) improved material accounting systems, especially for bulk-processing facilities; and (e) new technologies to address emerging security threats, such as drones.

- **Continue HEU minimization efforts.** The United States, Russia, and applicable third countries should continue efforts on HEU minimization, including additional fuel removals under the Russian Research Reactor Fuel Return program. Similarly, the United States, Russia, and other countries with HEU research reactors should—where technically and economically feasible—convert from the use of HEU to the use of LEU fuel. Each country should develop a strategic plan on HEU minimization, identifying opportunities for conversion or consolidation of existing HEU-fueled facilities.

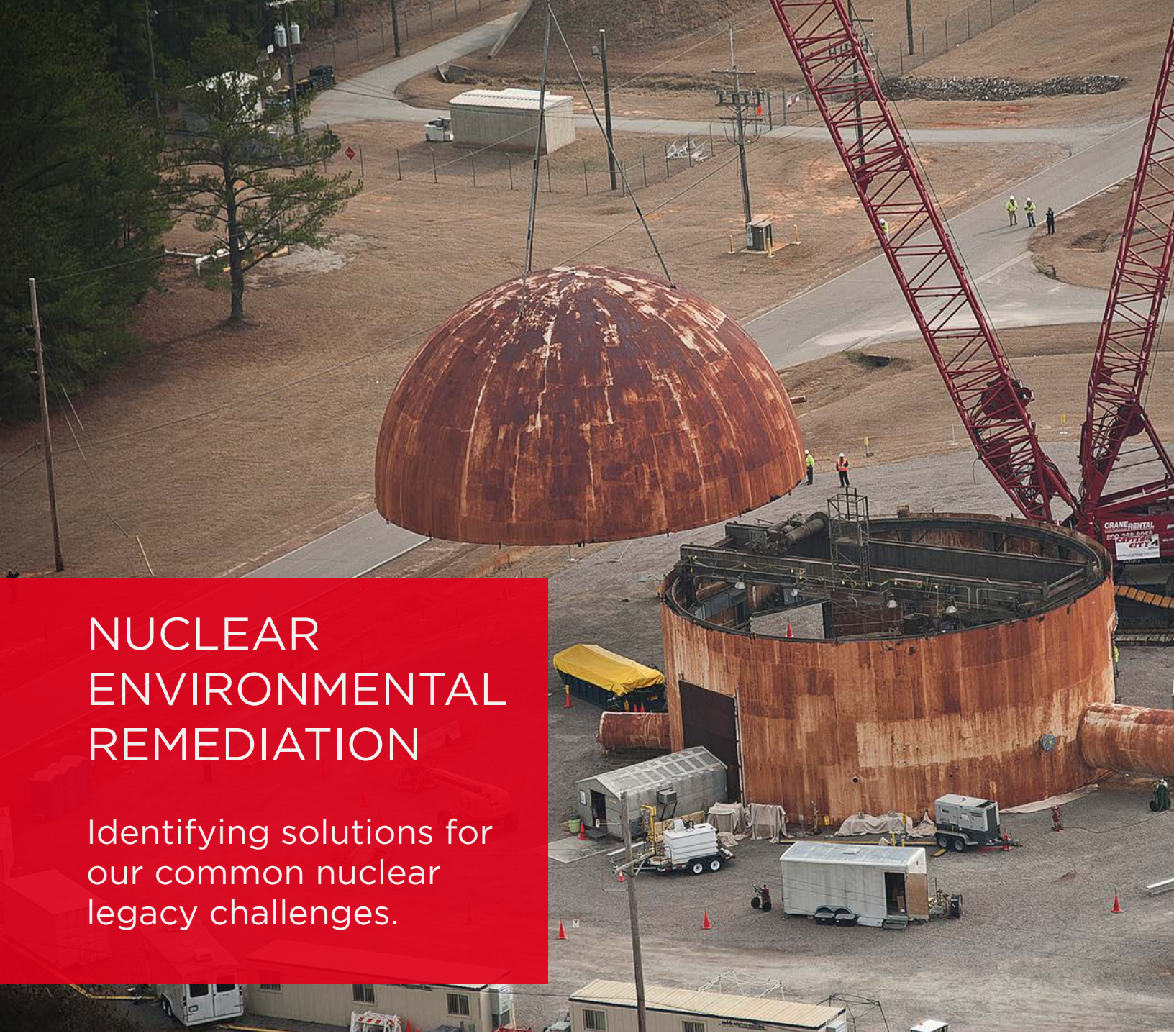
- **Cooperate to enhance nuclear security in nuclear newcomer countries.** Russian and U.S. experts can cooperate in improving nuclear security in countries seeking to develop nuclear power plants. In particular, it would be important to work together (and with the IAEA) to establish effective nuclear security approaches from the outset in newcomer states—including effective nuclear security regulation—to ensure that new nuclear reactors in these countries are well protected from sabotage and terrorist attack.

- **Cooperate to block illicit trafficking of nuclear and radioactive materials.** Russian and U.S. experts could work together to bolster efforts to block illicit trafficking of nuclear and radioactive materials. Cooperation could include such measures as (a) helping third countries establish and operate counter–nuclear smuggling teams trained and equipped to investigate illicit trafficking in nuclear and radioactive materials; (b) coordinating additional deployments of radiation detection equipment at international border crossings and internal checkpoints; and (c) improving international communication between law enforcement, border patrol, and customs agencies to interdict illicit trafficking. This cooperation should be undertaken in conjunction with related efforts by INTERPOL and the IAEA.

- **Establish a bilateral forum for nuclear forensics cooperation.** Russia and the United States have some of the world's leading experts in nuclear forensics—developed over decades of analyzing debris from nuclear tests during the Cold War. Although both Russian and U.S. experts participate in the International Technical Working Group on Nuclear Forensics, there has otherwise been little cooperation. Expanded bilateral cooperation would allow scientists in each country to learn from the other and to better prepare national libraries of data on the characteristics of their nuclear materials.

- **Cooperate on emergency preparedness and response.** Joint exercises between the United States and Russia are needed to ensure that key officials on each side know who their counterparts are and how to contact them and that they have practiced the steps that might need to be taken together in the event of a nuclear or radiological emergency. Exercises could cover issues ranging from search, identification, and render-safe activities focused on illicit nuclear or radioactive materials or devices to management of the consequences of an accident or terrorist attack. In addition, technical cooperation in all of these areas could help improve capabilities to respond to terrorist attacks or other nuclear or radiological emergencies. Furthermore, this cooperation could be extended to other countries to build their capacities for emergency preparedness and response. This collaboration could be particularly productive under the auspices of the Global Initiative to Prevent Nuclear Terrorism, which has a Response and Mitigation Working Group geared particularly toward these types of exercises and joint trainings.

- **Facilitate the creation of the Central Asian HEU-Free Zone.** Kazakhstan is the only remaining country in the region with any HEU holdings, nearly all of which are contained in the spent nuclear fuel originating from the BN-350 reactor, now stored in Semipalatinsk. The United States, Russia, and Kazakhstan could partner to determine a permanent disposition pathway for the remaining HEU, which would allow Central Asia to become HEU free. The countries in the region, working with the United States and Russia, could then work toward establishing a permanent HEU-Free Zone with commitments from each of the participating countries to refrain from developing HEU-using facilities. Reaching such an agreement would serve as a major nonproliferation achievement for the region and for the international community.



NUCLEAR ENVIRONMENTAL REMEDIATION

Identifying solutions for our common nuclear legacy challenges.

The United States and Russia share a common legacy of aged and surplus nuclear facilities, nuclear waste in need of treatment and disposal, and soil and groundwater in need of remediation. In addition, both nations have obsolete nuclear power plants that have reached the end of their useful lives and are ready for decommissioning. Both countries would benefit significantly from improved cooperation to lower the costs and risks posed by cleaning up their respective nuclear complexes with similar legacy challenges.

In addition, the United States and Russia should share best practices, experiences, and lessons learned pertaining to nuclear environmental remediation with other countries facing similar challenges. As global demand for nuclear energy increases, there will be a growing imperative to address the complex waste management and other legacy issues associated with nuclear power. The United States and Russia should work together, as well as with international organizations such as the IAEA, to address these challenges in order to ensure the long-term viability of nuclear energy.

Both countries should work together, along with the IAEA, to address nuclear environmental remediation challenges in order to ensure the long-term viability of nuclear energy.

Toward this end, the United States and Russia should reestablish a bilateral dialogue to share experience, expertise, best practices, and innovative methods on environmental remediation. The governments should use this framework to develop recommendations for the optimization of environmental remediation efforts in order to accelerate them and to implement them more cost-effectively.

Prospective projects for nuclear environmental remediation could include the following:

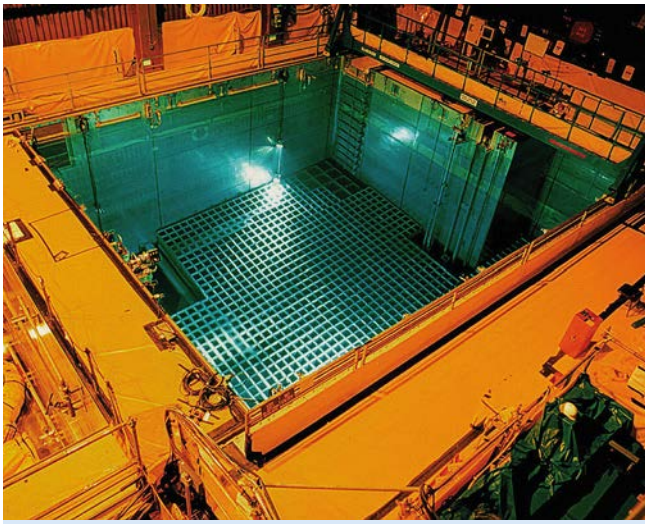
- **Develop common approaches to nuclear site and facility decommissioning and restoration.** Conditions at certain U.S. and Russian nuclear facilities provide uniquely valuable data for modeling contaminant mobility. Developing common cleanup approaches at these sites could also help both countries meet their environmental remediation goals. U.S.-Russian cooperation could also extend to other countries with similar environmental problems. For example, more than 350 nuclear installations worldwide—including research reactors, medical isotope production facilities, and radioactive materials disposal sites—are ready for closure, decommissioning, or remediation. Applying U.S. and Russian experience to other countries could provide benefits to each nation and to the global nuclear industry.
- **Build on national experience in waste processing and nuclear materials disposition.** Russia and the United States have a great deal of experience in waste processing and nuclear materials disposition. Working together, the two countries could overcome some of the principal technical challenges in these fields. Cooperative waste-processing projects could focus on developing advanced waste forms, understanding waste form chemistry and behavior (i.e., mechanisms for fission product and actinide incorporation into crystalline matrices), and modeling the long-term performance of waste forms. Cooperative materials disposition projects could focus on (a) spent nuclear fuel receipts, (b) storage transportation and disposition, (c) the specifics of plutonium storage and disposition, (d) corrosion and materials integrity (for storage containers, spent fuel, etc.), (e) materials characterization and characterization technologies, and (f) remote inspection and in situ immobilization and closure.
- **Research and develop environmental remediation technologies.** U.S. and Russian technical experts should collaborate on innovative environmental remediation techniques in areas such as (a) decontamination of uranium mining and processing centers and of radioactive source disposal sites, (b) accelerated deactivation methods, (c) waste conditioning of scrap metals and in reactor decommissioning, (d) use of robotic segmenting and cutting technologies, and (e) field waste segregation techniques to minimize disposal costs and accelerate schedules. In addition, experts should explore prospects for deep borehole disposal and should identify methods of achieving regulatory acceptance of alternative closure end states.

- **Develop improved approaches to contaminated soil and groundwater remediation.** Russia and the United States face similar challenges in remediating contaminated soil and groundwater. Cooperative projects could focus on (a) site characterization and contaminant modeling; (b) performance assessments and modeling; (c) advanced modeling and simulation critical to predicting contaminant fate and transport; (d) monitoring, access, control, and delivery of remedial action in the deep vadose zone; (e) deepening of the knowledge of biogeochemical gradients and permeable reactive barriers; (f) promotion of natural attenuation and development of enhanced remediation technology; and (g) assurance of long-term monitoring and data management. Attention should also focus on transformational remediation technologies and green and sustainable remediation.

- **Decommission nuclear facilities in Central Asia and other countries in the Commonwealth of Independent States (CIS).** Russia and the United States should create a mechanism for dialogue with Armenia, Belarus, Kazakhstan, and Uzbekistan on decommissioning nuclear energy facilities, including research reactors. Other interested parties should also be invited to join. The dialogue should share experience and expertise and should develop recommendations and a decommissioning methodology. Russia could share its expertise and formulate recommendations on the basis of projects already completed with foreign partners, especially participating CIS states. Given the country's advanced nuclear energy program and the expertise of the Sosny Joint Institute for Power and Nuclear Research of the Belarusian Academy of Sciences, Belarus could be a particularly active participant in this work.

- **Remediate former uranium production sites (tailing dumps) in Central Asian states.** As a result of large-scale uranium mining and processing activities during the Soviet period, Central Asian states have inherited large amounts of radioactive waste at tailing dumps. Russia and the United States should take the lead in setting up a standing Russian-U.S.-Central Asian consultative body to help manage this legacy. Priority projects include (a) phased remediation of the worst-affected sites, (b) measures to reduce the risk of emergencies involving radioactive contamination, and (c) the harmonization of national legislation and environmental and public health monitoring. Leveraging national and international expertise will reduce the time and cost of each project through coordinated use of investment, labor, industrial resources, and infrastructure. Such cooperation would augment efforts being undertaken by international and intergovernmental organizations.

- **Develop tank waste-processing technology.** The U.S. Department of Energy has 88 million gallons of liquid waste stored in underground tanks and approximately 4,000 cubic meters of solid waste derived from the liquids stored in bins. The current estimate for retrieval, treatment, and disposal of this waste exceeds $50 billion over several decades. The highly radioactive portion of this waste—located at the Hanford National Laboratory in Idaho and the Savannah River National Laboratory in South Carolina—must be treated, immobilized, and prepared for shipment to a repository. Efforts currently focus on improving pretreatment



A Spent Fuel Pool at the San Onofre Nuclear Generating Station, San Onofre, California, a decommissioned facility still containing nuclear waste.

SOURCE: U.S. Department of Energy

processes to reduce waste volumes, retrieval technologies, vitrification performance, and breakthrough immobilization technologies. Russia faces similar challenges with its high-level waste tank storage. Given these common circumstances, both countries could benefit greatly from a cooperative program that targets technical solutions to shared environmental remediation problems. Projects could focus on (a) options for chemical cleaning of tanks; (b) emerging technologies to assist tank waste removal, including robotic enhancements to current waste retrieval technologies; (c) R&D and testing and manufacture of technologies to improve waste tank integrity; (d) next-generation melter development; (e) in-tank treatment of waste; and (f) near- and long-term performance and monitoring of tank fill materials (i.e., grout).

- **Assess options for radioactive substances dumped off Russian and U.S. coasts.** A number of countries once disposed of radioactive waste in the oceans. Russia and the United States should set up a working group to exchange experience and conduct a joint risk assessment as well as a feasibility study to determine whether the waste should be retrieved from the ocean floor, made safer in situ, or left in place undisturbed.

- **Establish best-practice exchanges on environmental remediation project management.** The United States and Russia face similar budgetary, regulatory, and technological challenges, including limited federal funds to address legacy environmental challenges combined with competing demands for those funds and cost and schedule uncertainty for large projects. This constraint requires both countries to ensure that projects are conducted using an established method for measuring progress and for monitoring the cost and schedule in order to provide a foundation for innovative approaches. New projects involving the exchange of best practices and training on—and techniques for—effective project and program management could focus on (a) the challenges associated with whole site ("closure") types of decommissioning projects; (b) project management fundamentals, such as project definition, planning and control, project management essentials, scope management and baseline development, and cost and schedule estimation; (c) various project management tools; and (d) before-and-after case studies.

Potential Legal, International, and Intergovernmental Frameworks

The United States and the Russian Federation can use several existing legal bases and international frameworks to implement the projects described in this report. It is important to note, however, that many projects do not require new legal arrangements. They include projects involving industry-to-industry engagement, university partnerships, and ad hoc governmental meetings that do not require liability or information protections.

Existing Legal, International, and Intergovernmental Frameworks for Cooperation

The table on the following page lists the existing legal basis and intergovernmental (non-legally binding) frameworks that could be used to facilitate cooperation across the five thematic areas described in this report.

FRAMEWORKS FOR COOPERATION

THEMATIC AREA	APPLICABLE FRAMEWORK
NUCLEAR SCIENCE 	U.S.-Russian Agreement for Cooperation in the Field of Peaceful Uses of Nuclear Energy (U.S.-Russian 123 Agreement) U.S.-Russian Agreement on Cooperation in Nuclear- and Energy-Related Scientific Research and Development (R&D Agreement)* International Technical Working Group on Nuclear Forensics Generation IV International Forum
NUCLEAR ENERGY 	U.S.-Russian Agreement for Cooperation in the Field of Peaceful Uses of Nuclear Energy (U.S.-Russian 123 Agreement) U.S.-Russian Agreement on Cooperation in Nuclear- and Energy-Related Scientific Research and Development (U.S.-Russian R&D Agreement)* Multilateral initiatives implemented under the auspices of the International Atomic Energy Agency Industry-led initiatives implemented under the auspices of the World Association of Nuclear Operators
NUCLEAR SAFETY 	U.S.-Russian Agreement for Cooperation in the Field of Peaceful Uses of Nuclear Energy (U.S.-Russian 123 Agreement) U.S.-Russian Agreement on Cooperation in Nuclear- and Energy-Related Scientific Research and Development (U.S.-Russian R&D Agreement)* Multilateral initiatives implemented under the auspices of the International Atomic Energy Agency Organisation for Economic Co-operation and Development Nuclear Energy Agency's Nuclear Safety Research Working Group Industry-led initiatives implemented under the auspices of the World Association of Nuclear Operators
NUCLEAR SECURITY 	U.S.-Russian Agreement on Cooperation in Nuclear- and Energy-Related Scientific Research and Development (U.S.-Russian R&D Agreement)* Global Initiative to Combat Nuclear Terrorism 2013 Protocol to the Multilateral Nuclear Environmental Programme in the Russian Federation (2013 MNEPR Protocol) Multilateral initiatives implemented under the auspices of the International Atomic Energy Agency
NUCLEAR ENVIRONMENTAL REMEDIATION 	U.S.-Russian Agreement for Cooperation in the Field of Peaceful Uses of Nuclear Energy (U.S.-Russian 123 Agreement) U.S.-Russian Agreement on Cooperation in Nuclear- and Energy-Related Scientific Research and Development (U.S.-Russian R&D Agreement)* 2013 Protocol to the Multilateral Nuclear Environmental Programme in the Russian Federation (2013 MNEPR Protocol) Multilateral initiatives implemented under the auspices of the International Atomic Energy Agency

*Cooperation under this Agreement has been suspended but could be resumed at a later date.

New Legal Bases and International and Intergovernmental Frameworks for Cooperation

New initiatives could also be established to facilitate cooperation in many of these areas. In some instances, cooperative frameworks that have expired could be renewed.

Although many of the proposed projects can be undertaken through existing mechanisms, certain initiatives may best be suited for a new dedicated framework for cooperation.

These initiatives include the following:

- **A new "regulator-to-regulator" arrangement between the U.S. Nuclear Regulatory Commission and Rostechnadzor.** The memorandum of cooperation between the U.S. Nuclear Regulatory Commission and Rostechnadzor expired in 2012. A new arrangement is required to ensure effective cooperation between the two agencies. That arrangement should create a framework for the two countries to pursue joint projects in nuclear and radiation safety regulation with regard to the peaceful use of nuclear energy.
- **A new nuclear environmental remediation agreement between the U.S. Department of Energy and Rosatom.** In 2014, the bilateral agreement between the U.S. Department of Energy and Rosatom on cooperation in research on radiation effects for the purpose of minimizing the consequences of radioactive contamination on health and the environment expired. A new bilateral document should be negotiated to serve as a framework for U.S.-Russian cooperation in environmental remediation.
- **A new bilateral mechanism to reinvigorate efforts to prevent terrorism using weapons of mass destruction (WMD).** A joint U.S.-Russian initiative to prevent WMD terrorism could be a useful mechanism to spur intergovernmental cooperation to prevent terrorists from acquiring materials of concern, including weapons-usable nuclear materials and radioactive sources. This pressing issue requires a targeted response and dedicated resources. A dedicated legal framework would allow certain stakeholders from both countries to participate.
- **A new standing high-level mechanism for coordinating future cooperation.** The projects identified in this report are best served by a bilateral coordinating body that manages and directs implementation. A renewed bilateral forum modeled after the successful Nuclear Energy and Nuclear Security Working Group (Poneman-Kirienko Working Group) could serve as a basis for future iterations of U.S.-Russian cooperative efforts.

Conclusion

This report concludes that renewed U.S.-Russian cooperation on nuclear issues would provide considerable benefits to both countries and to the international community. From combating climate change through safe nuclear energy expansion to preventing nuclear terrorism, the benefits of cooperation far outweigh the political costs of engagement.

The more than 50 projects outlined in this report offer a wide range of opportunities for both countries to use their nuclear expertise to tackle persistent challenges in energy sustainability, public health and safety, global security, and environmental protection. The project list illustrates the universe of potential bilateral projects that could serve both countries' interests if stakeholders in both countries engage.

Complementary R&D could lead to breakthroughs in nuclear science that would support the next generation of safe, proliferation-resistant nuclear reactors or would lead to the development of new detectors that could more effectively discriminate and identify smuggled radiological material.

Bilateral engagement on nuclear energy could lead to advances in reactor and fuel development, increasing the market competitiveness of nuclear power while enhancing the safety and reliability of nuclear reactor operation. Partnership in nuclear energy also promotes both countries' shared vision to reduce greenhouse gas emissions and to engage alternatives to carbon-based energy sources.

Revitalizing U.S.-Russian nuclear safety cooperation could provide opportunities for regulators, industry, and scientific communities to improve incident response, strengthen safety culture, and ensure the safe construction and operation of nuclear facilities worldwide, taking into account lessons learned from the Fukushima nuclear disaster. As nuclear exporters, both countries also have a responsibility to guide and support regulatory development and improvements to the safety culture in nuclear newcomer countries.

As stewards of the world's two largest nuclear enterprises and as major nuclear exporters, the United States and Russia hold immeasurable responsibility for bilateral and multilateral engagement on nuclear security. Cooperation in nuclear security, based on the principles of mutual benefit and reciprocity, can reduce the risk of nuclear or radiological terrorism while providing a basis for engagement with other countries on preventing illicit trafficking, securing nuclear materials, and improving radiological source security in key areas of concern, including Central Asia and the Middle East.

Finally, the United States and Russia continue to face major common challenges to addressing the environmental impact of our respective nuclear legacies and the nuclear activities of third countries. Jump-starting cooperation on nuclear environmental remediation, particularly on R&D, could help both countries explore novel approaches to solving common spent fuel management challenges and renew technical engagement on a topic with critical implications for the expansion of nuclear energy worldwide.

If relations between the United States and Russia continue to deteriorate, and projects such as those offered in this report are ignored, then both countries stand to lose a crucial opportunity. The risk of nuclear terrorism will grow, investments in carbon-free nuclear energy will stagnate, and both countries' nuclear environmental legacy challenges will worsen.

The choice for policymakers should be clear: commonsense nuclear cooperation that benefits both countries should be a priority. The differences between the United States and Russia today, though serious, must not be allowed to block nuclear cooperation. Their partnership in the nuclear sphere is simply too important to sacrifice.

About the Project

At a time of strained relations between the world's two largest nuclear powers, maintaining channels of communication between experts has taken on new significance. Over the past three years, relations between Moscow and Washington have dramatically deteriorated, prompting a suspension of most bilateral engagement on nuclear issues. The resulting absence of cooperation has created dangerous conditions, breeding mutual antagonism and eroding the trust developed over decades of collaboration among scientists, technical experts, and industry representatives.

These troubling developments compelled NTI and CENESS to seek new channels of communication and to imagine what future cooperation might look like—and the benefits derived from such positive engagement. As a result, in 2015, NTI and CENESS launched a joint project to identify pathways for resumed cooperation in five thematic areas: nuclear science, nuclear energy, nuclear safety, nuclear security, and nuclear environmental remediation.

In February 2016, NTI and CENESS convened a major conference in Moscow, bringing together 55 leading nuclear experts from the United States and Russia to discuss specific proposals regarding the future of U.S.-Russian nuclear cooperation. The discussions led to the development of the menu of projects described in this report, which could be implemented as bilateral relations improve.

Experts participating in the conference did not represent the views or interests of their countries. Participation in the conference does not imply concurrence with every aspect of this report or its recommendations. The views expressed in this report do not necessarily reflect those of the institutions with which the participants are associated; their affiliations are listed for the purpose of identification only.

Participants

The following individuals participated in the February 2016 NTI-CENESS Dialogue on the Future of U.S.-Russian Nuclear Cooperation:

Steven Aoki, Independent Consultant; former Deputy Under Secretary of Energy for Counterterrorism, United States

Alexei Arbatov, Head, Center for International Security, Institute of World Economy and International Relations (IMEMO), Russian Academy of Sciences, Russian Federation

Vladimir Artisyuk, Vice-Rector for International Cooperation, Central Institute for Continuing Education and Training (CICET), Rosatom State Energy Corporation, Russian Federation

Andrew Bieniawski, Vice President, Nuclear Threat Initiative; former Assistant Deputy Administrator for Global Threat Reduction, National Nuclear Security Administration (NNSA), United States

Leonid Bolshov, Director, Nuclear Safety Institute (IBRAE), Russian Academy of Sciences, Russian Federation

Matthew Bunn, Professor of Practice, Harvard University; former Advisor to the Office of Science and Technology Policy (OSTP), Executive Office of the President of the United States, United States

Cathleen Campbell, President and CEO, CRDF Global, United States

Charles Curtis, President Emeritus, Nuclear Threat Initiative; former Deputy Secretary of Energy, United States

Anatoly Diakov, Chief Research Associate, Center for Arms Control, Energy and Environmental Studies; Associate Professor, Moscow Institute of Physics and Technology (MIPT), Russian Federation

Alexandr Dmitriev, former Deputy Director, Russian Federal Inspectorate for Nuclear and Radiation Safety (Gosatomnadzor), Russian Federation

Andrey Gagarinskiy, Advisor to the Director General, National Research Center (Kurchatov Institute), Russian Federation

Valery Govorukhin, First Deputy Director General for Strategy and Communications, Tenex, Rosatom State Energy Corporation, Russian Federation

Siegfried Hecker, Professor, Stanford University; former Director, Los Alamos National Laboratory, United States

Igor Ivanov, President, Russian International Affairs Council (RIAC); former Foreign Minister; former Secretary of the Security Council, Russian Federation

Alexander Izmaylov, Advisor to the Director General, Eleron, Rosatom State Energy Corporation, Russian Federation

Alla Kassianova, Senior Research Associate, Stanford University, United States

Carol Kessler, Principal, NorthRaven Consulting LLC; former Chair, Nonproliferation and National Security Department, Brookhaven National Laboratory, United States

Anton Khlopkov, Director, Center for Energy and Security Studies (CENESS), Russian Federation

Alexandr Koldobski, Deputy Director, Institute of International Relations, National Research Nuclear University MEPhI, Russian Federation

Dmitry Konukhov, Research Associate, Center for Energy and Security Studies (CENESS), Russian Federation

Dmitry Kovchegin, Independent Consultant, Russian Federation

Nikolay Kravchenko, Associate Professor, National Research Nuclear University MEPhI; Founding Head, Directorate for Customs Control of Fissile Materials and Radioactive Sources of the Federal Customs Service, Russian Federation

Vladimir Kuchinov, Advisor to the Director-General, Rosatom State Energy Corporation, Russian Federation

Dan Lipman, Vice President, Nuclear Energy Institute; former Senior Vice President, Westinghouse Electric Company, United States

Paul Longsworth, Vice President, International Nuclear & Environmental, Fluor Corp.; former Deputy Administrator for Defense Nuclear Nonproliferation, National Nuclear Security Administration (NNSA), United States

Micah Lowenthal, Director, Committee on International Security and Arms Control (CISAC), National Academy of Sciences, United States

Mikhail Lysenko, Advisor, Center for Energy and Security Studies (CENESS); former Director, Department for International Cooperation, Rosatom State Energy Corporation; former Director, Department for Security and Disarmament, Foreign Ministry, Russian Federation

Galina Manilovskaya, Director, Department of Strategic Communications, Tenex, Rosatom State Energy Corporation, Russian Federation

Victor Murogov, Director, International Center for Nuclear Education; former Director, Leipunski Institute of Physics and Power Engineering (IPPE); former Deputy Director General, International Atomic Energy Agency, Russian Federation

Ivan Nasteka, Intern, Center for Energy and Security Studies (CENESS), Russian Federation

Thomas Neff, Physicist, Massachusetts Institute of Technology, United States

Andrew Newman, Senior Program Officer, Nuclear Threat Initiative, United States

Vladimir Novikov, Senior Research Associate, Russian Institute of Strategic Studies (RISS), Russian Federation

Sam Nunn, CEO and Co-Chairman, Nuclear Threat Initiative; former U.S. Senator, United States

Ekaterina Paramonova, Non-Resident Research Associate, Center for Energy and Security Studies (CENESS), Russian Federation

Sergey Ponamarev, Second Secretary, Department for Nonproliferation and Arms Control, Ministry of Foreign Affairs, Russian Federation

Daniel Poneman, CEO, Centrus Energy; former Deputy Secretary of Energy, United States

Charles Powell, Herbert Scoville Jr. Peace Fellow, Nuclear Threat Initiative, United States

Leon Ratz, Program Officer, Nuclear Threat Initiative, United States

Christopher Rendo, Counselor, Environment, Science, Technology & Health Section, Embassy of the United States to the Russian Federation

Nickolas Roth, Research Associate, Managing the Atom Project, Harvard University, United States

Sergey Ryabkov, Deputy Foreign Minister, Russian Federation

Yuri Seleznev, Rector, Central Institute for Continuing Education and Training (CICET), Rosatom State Energy Corporation, Russian Federation

Jon Shearer, Director, Department of Energy Office in Moscow, Embassy of the United States to the Russian Federation

Yuri Shiyan, Deputy Head, External Relations Department, Russian Academy of Sciences (RAS), Russian Federation

Nikolay Spasskiy, Deputy Director-General, Rosatom State Energy Corporation, Russian Federation

John Tefft, United States Ambassador to the Russian Federation

Will Tobey, Senior Fellow, Belfer Center for Science and International Affairs, Harvard University; former Deputy Administrator for Defense Nuclear Nonproliferation, National Nuclear Security Administration (NNSA), United States

Mikhail Tolchenov, First Secretary, Department of North America, Ministry of Foreign Affairs, Russian Federation

Joseph Tordella, Deputy Press Attaché, Embassy of the United States to the Russian Federation

Boris Tulinov, Director, Institute of International Relations, National Research Nuclear University MEPhI, Russian Federation

Alexei Ubeev, former Head, Nuclear Non-Proliferation, Safety and Security Division, Ministry of Foreign Affairs; former Deputy Director, Department for International Cooperation, Rosatom State Energy Corporation; former Senior Nuclear Security Officer, International Atomic Energy Agency, Russian Federation

Frank von Hippel, Professor, Princeton University; former Assistant Director for National Security, Office of Science and Technology Policy (OSTP), Executive Office of the President of the United States, United States

Lyudmila Zalimskaya, Director General, Tenex, Rosatom State Energy Corporation, Russian Federation

Anatoly Zrodnikov, Deputy Director General for Science, All-Russian Research Institute for Nuclear Power Plants Operation (VNIIAES); former Director, Leipunski Institute of Physics and Power Engineering (IPPE), Russian Federation

Center for Energy and Security Studies
www.ceness-russia.org

About the Center for Energy and Security Studies

The Center for Energy and Security Studies (CENESS) is an independent, non-governmental think-tank established in 2009. Headquartered in Moscow, the main goal of CENESS is to promote independent, unbiased, systematic, and professional analyses related to nuclear nonproliferation and atomic energy with a special emphasis on international cooperation of Russia in these areas. The founding director of the Center is Mr. Anton Khlopkov.

About the Nuclear Threat Initiative

The Nuclear Threat Initiative works to protect our lives, environment, and quality of life now and for future generations. We work to prevent catastrophic attacks with weapons of mass destruction and disruption (WMDD)—nuclear, biological, radiological, chemical, and cyber. Founded in 2001 by former U.S. Senator Sam Nunn and philanthropist Ted Turner, NTI is guided by a prestigious, international board of directors. Sam Nunn serves as chief executive officer; Des Browne is vice chairman; and Joan Rohlfing serves as president.

This report is available for download as a PDF in Russian and English at ww.nti.org and www.ceness-russia.org

FROM THE FOREWORD BY SAM NUNN AND IGOR IVANOV

The United States and Russia today face no shortage of disagreements. From Syria to Ukraine, the differences are serious and stark, but they should not obscure another important truth—that the United States and Russia have mutual, converging interests on some of the most consequential issues of today. Among them is the shared responsibility to manage the destructive forces of the atom while directing those same forces toward positive applications, such as combating climate change.

NTI
BUILDING A SAFER WORLD

Nuclear Threat Initiative
1747 Pennsylvania Ave NW, 7th Floor
Washington, D.C. 20006
www.nti.org

Center for Energy and Security Studies
www.ceness-russia.org

Center for Energy and Security Studies
(Центр энергетики и безопасности)
Mosfilmovskaya Str., 42
Bldg. 1
Moscow, Russia 119285
www.ceness-russia.org