Global Nexus Initiative

Where Climate, Nuclear, and Security Meet

Evolving Nuclear Governance for a New Era

Policy Memo and Recommendations

April 2017

This report is based on discussions of the Global Nexus Initiative (GNI) Working Group at its June 2016 workshop held in Washington, D.C.

Evolving Nuclear Governance for a New Era

POLICY MEMO AND RECOMMENDATIONS

Overview

Strengthening the global nuclear governance system is essential to maintaining the important contribution of nuclear power in addressing climate change while assuring achievement of vital nuclear safety, security, and nonproliferation objectives. Nuclear governance is a complex national and international legal and technical system that requires continuous improvement to adapt to the evolving international environment and effectively address its challenges. Its effectiveness has a direct impact on nuclear operations and expansion as well as on the global public's confidence in nuclear power.

The current governance system encompasses the critically important nuclear safety, security, and safeguards regimes and essential issues related to environmental impacts. It covers a wide range of national regulations and laws, international agreements and guidance, and facility operations and practices. At the global level, the primary institution responsible for nuclear guidance is the International Atomic Energy Agency (IAEA). At the national level, it is governed by domestic laws and regulatory authorities. In addition, there are several nuclear industry and non-governmental professional institutions, including the World Association of Nuclear Operators (WANO), the Institute of Nuclear Power Operations (INPO), and the World Institute for Nuclear Security (WINS) that develop and share "best practices" that extend beyond regulatory standards.

Over the past six decades, the nuclear governance system has adapted to new requirements and events, but this process has been more episodic and reactive than strategic. This system now faces technical evolution, systemic stresses, and threat vectors unlike those of previous eras, and its responses to them need to be more proactive, rapid, and effective. One example is the potential for nuclear terrorism. Terrorists with few moral limits are seeking access to nuclear materials, facilities, and weapons. Other challenges include cyber security, materials technology, and next generation nuclear reactors, all of which are racing forward while the governance system lags behind.

A particular challenge is being posed by the evolution of nations seeking nuclear power and those that seek to supply them. Nuclear power is most rapidly growing in tense regions

About GNI

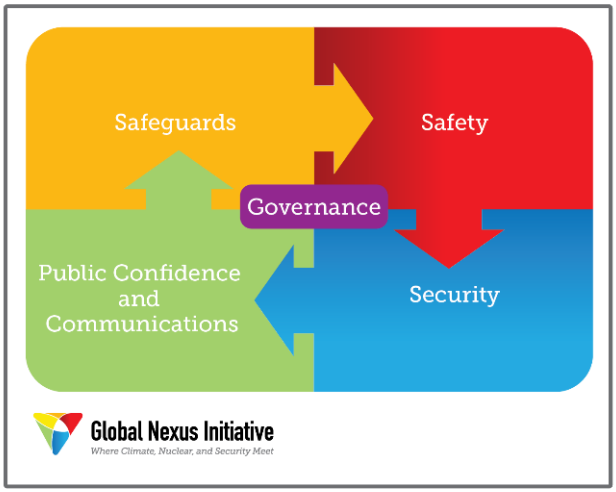
Formed in 2015, the Global Nexus Initiative (GNI) brings together for the first time experts from the nuclear industry, nuclear security and environmental communities to examine the complex challenges posed by the intersection of climate change, energy demand and global security. The GNI is co-sponsored by the Partnership for Global Security and the Nuclear Energy Institute.

of Asia and slowly emerging in the stability-challenged Middle East. It is projected that China will overtake the United States as the world's top nuclear power generating nation by 2026, making it the largest global nuclear operator and market.[1] By contrast, western countries are building few new reactors and are focused on preserving existing plants and preparing for a possible bow wave of decommissioning at mid-century.

The nuclear supplier situation also is changing rapidly, and it has the potential to impact the effective application of established international norms and their evolution. Along with its significant nuclear construction program, China is seeking to sell and build nuclear plants to emerging economy nations as well as the West. The state-owned China General Nuclear Power Corporation will have a 33.5% stake in the British Hinkley Point nuclear power project. According to some reports, this was a strategic decision that China intends to use as a "springboard" for other nuclear deals.[2] Russia is offering a build, own, operate model that provides cradle-to-grave financing, operational expertise, fuel, decommissioning services, and spent fuel disposal. South Korea is supplying the four reactors being built in the United Arab Emirates and will manage their operation.[3] These developments are unique, as the traditional model requires the recipient nation to indigenously operate their plants. It also is important because in a number of new nations seeking nuclear power, there are questions about the adequacy of the human and technical infrastructure that is necessary to safely and securely sustain this complex equipment or prevent its misuse.

An aggressive and effective response to these new realities - strengthening, unifying, and when necessary expanding the nuclear governance system - is essential for nuclear power to continue to play a vital role in meeting the intensifying global need for carbon-free energy in the 21st century.

An evolution of the nuclear governance system will require significant changes in a number of areas. New policies will need to be developed. Governments and international institutions will need to be more receptive to governance changes and enhancements. The nuclear industry will need to be an active a partner in achieving progress. And, relationships among diverse stakeholders that are based on cooperation in support of a common agenda, need to be strengthened and institutionalized.



Findings and Recommendations

The following findings and recommendations are based on the Global Nexus Initiative's June 2016 workshop on *Nuclear Governance in a New Era: Challenges and Responsibilities*.

Finding I: The Nuclear Governance System Must Effectively Respond to New Challenges

The global nuclear governance system is facing a series of new challenges that require effective responses. As the number of nuclear reactors grows worldwide, in response to the need for carbon-free energy and to meet national energy demands, the governance system will be taxed with ensuring the safety and security of a larger number of nuclear plants and materials. The nuclear supplier situation is in flux, with South Korea and soon China joining Russia in aggressively pursuing market share. They are offering operational and financing support that is particularly attractive to newcomer nuclear nations.

But the challenges are growing. Cyber security threats are evolving rapidly and threaten all aspects of critical infrastructure, including the energy sector. The international nuclear security system continues to lag behind the nuclear safety and nonproliferation regimes in terms of transparency, comprehensiveness and effectiveness. As new countries pursue nuclear power and others seek to expand it, they must ensure that strong institutional, regulatory, managerial, and educational systems are in place. These are particularly significant tasks for newcomer nuclear states as these issues already have proven to be challenges in nations with well-developed and long-standing nuclear infrastructure.

Recommendations

1. A key nuclear governance principle that needs to be established and widely accepted is "realistic continuous improvement." This means that the system requires regularized attention to identify gaps and weaknesses and that actions should be taken on a rolling basis to address these issues and new challenges that may arise. Continuous improvement requires identifying problems and challenges and addressing them proactively, not in response to an incident. The emphasis on realistic improvement is to ensure that all actions taken positively impact nuclear operations and strengthens the system against known and potential dangers. The goal is to strengthen weak links and improve safety and security culture, but not impede operations and progress.

2. The nuclear security regime, in particular, needs to be strengthened and universalized along with the nuclear safety and safeguards systems. For nuclear security, this will require a move toward common standards, greater transparency of non-sensitive information, expansion of peer reviews, sharing of best practices, and consideration of an international agreement on nuclear security. The safeguards regime has been strengthened by the introduction of the Additional Protocol that grants the IAEA the authority to verify a state's safeguards obligations including at undeclared facilities. But, there are still nations that have not brought it into force. There should not be complacency with the existing nuclear safety system and improvements should continually be sought. The Convention on Nuclear Safety requires peer reviews, for example, but does not have an enforcement mechanism. The IAEA's international safety standards are non-binding, and it does not have the authority to conduct an inspection without an invitation from the Member State.

Finding II: Improving Nuclear Governance Requires a New Strategic Alliance

The improvement of nuclear governance cannot effectively be done by any one stakeholder community in isolation or by any institution alone. It requires a strong coalition among governments; the nuclear industry and its professional associations; and the nuclear nonproliferation, security, and safety expert communities. Together, and in collaboration with relevant international organizations, they can assess the requirements for improvement and formulate balanced and needed advances in the system. This integrated approach to strengthening the nuclear governance system can improve the chances that the necessary changes will be made, that they will not have unintended impacts, and that they will advance global safety and security. The foundation for this strategic alliance has been created, but significant additional work is required to institutionalize it and overcome past divisions (real and artificial) between these communities. An important part of that effort is the need to improve communication on nuclear governance issues and messaging effectively on its value.

Recommendations

1. Initiatives that have begun to create strong strategic alliances among the key nuclear governance stakeholder communities should be expanded, strengthened, and institutionalized. The Global Nexus Initiative is one example of this new approach that has brought the nuclear industry and civil society into closer collaboration. Another example is the Nuclear Industry Steering Group for Security (NISGS). This is an industry initiative that seeks to continue the role that nuclear companies played during the Nuclear Security Summits (NSS) and strengthen its relationship with governments and the IAEA. The NISGS should create an opportunity for regularized collaboration with non-governmental experts on nuclear security issues, and the expert community should organize itself to effectively interact with this group. Additional initiatives that can further strengthen these relationships should be developed and supported.

2. The development of effective and approachable communication and messaging on the importance of nuclear governance and its improvement requires more attention and honing to increase its salience and value. A key part of the strategy for improving nuclear governance is the ability to communicate effectively to the public and all stakeholders on the value of steps being taken to continually strengthen the management and oversight of nuclear operations. The nuclear landscape is highly technical, and in general, the global public is not knowledgeable about the in-depth aspects of its operations.

Finding III: The Evolution of Nuclear Suppliers is Challenging International Standards

The nuclear supplier landscape is evolving rapidly, with Russia, South Korea, and soon China aggressively marketing their technology and services. Traditional suppliers, including the United States, France, and Japan are at risk of largely becoming sub-contractors in new nuclear reactor builds. This raises questions about how effectively the existing nuclear governance system will be implemented and where the impetus for improvement will originate. The major nuclear states of the West have played a significant role in the development of the existing regimes. However, traditional leading suppliers, including U.S.-based Westinghouse and France's AREVA are currently facing significant financial problems. If the involvement of previously dominant suppliers declines, their ability to drive international governance implementation and improvement will also be reduced. The emerging suppliers do not have a deep record of initiating or recommending major improvements to the global nuclear governance system. But, to be viewed as responsible suppliers, they must become more active in this process. For example, the Nuclear Power Plant and Reactor Exporters' Principles of Conduct (Principles of Conduct) was designed to enhance national and international governance and oversight of nuclear exports. [4] It has included support from major companies from the United States, Japan, France, South Korea, Argentina, and Russia. No organization from China agreed to participate in the initiative. Unfortunately, participation in the Principles of Conduct is waning and continuation of this effort is unlikely.

Recommendations

1. The emerging nuclear suppliers must demonstrate an enduring commitment to protecting and instituting existing norms and exhibit a willingness to take leadership in initiating improvements in the nuclear governance system.

2. Existing suppliers, particularly in the United States, Japan, and Europe, must maintain strong influence in ensuring that existing norms are maintained and are not compromised. They also must retain adequate influence to continue to move the supplier norms in a positive direction. Achieving these objectives will be easier and more effective if these countries maintain active nuclear programs and continue active engagement with international partners on technology and regulatory development.

3. There needs to be a greater appreciation for the impact that nuclear supply has on the political and strategic objectives of the recipient and supplier nations. A cooperative relationship must be created that can last for up to 100 years to encompass the full term of reactor building, operation, and decommissioning. Ignoring the geopolitical implications of this relationship can impact a range of foreign policy, security, and economic interests of various nations, including the ability to strengthen the nuclear governance system.

Finding IV: Nuclear Newcomers Require a More Effective Nuclear Governance System

The locus of nuclear activity is moving from established nuclear nations to developing countries and newcomer states. These are regions where political tensions and security risks are high, including in the Middle East and South East Asia. The new wave of nuclear operating states, in general, exhibit weaker rule of law, less regulatory independence, and decreased nuclear technical and training depth. From the perspective of climate change, some assessments have identified a requirement for 4,000 Gigawatts of nuclear power worldwide.[5] Depending on the size of each unit, this could be 2,000-4,000 reactors. While, it is unlikely that there will be several thousand new Light Water Reactors (LWR) deployed to meet atmospheric carbon reductions, the combination of LWRs and advanced reactors could double the current number of reactors worldwide to more than 1,000. Advanced reactors in particular may appeal to developing economy nations because of their ability to provide distributed power and the possible ease of deployment. This growth will place a significant strain on the existing governance system and little has been done to think through the requirements of a system that would be essential for the safe and secure operation of a fleet of reactors of this size that includes traditional light-water and advanced technologies.

Recommendations

1. Additional assistance from experienced nuclear operating states is required to support newcomer nuclear nations in preparing for and effectively and safely operating nuclear power installations. This task should be shared with the IAEA, which is already very active in this area.[6] A clear focus must be on assessing the needs of the nuclear newcomers in order to establish the regimes required to ensure the safe, secure, and proliferation-resistant operation of any plant.

2. Nations deploying a significant number of additional nuclear power reactors and those developing advanced reactors, in cooperation with the IAEA, need to address in greater detail how the nuclear governance system will adapt to a potential significant increase in the number of reactors worldwide and the multi-technology environment that may develop by mid-century.

Current Regime

The current nuclear governance regime is a complex and comprehensive global framework that has worked relatively well overall, but it has continual challenges and is not necessarily optimized to address new issues. It includes national laws and regulations, international agreements, and less formal recommendations and best practices. It covers the core issues of nuclear safety, security, nuclear proliferation prevention, and the environmental legacy of nuclear power. But, not all of these issues are addressed equally.

At the core of the nuclear safety regime is the Convention on Nuclear Safety (CNS).[7] It mandates that nations regularly assess the strength of their nuclear safety practices and subject these procedures to international peer review. The nuclear safety regime also benefits from support from non-governmental professional associations including INPO and WANO. This system has been developed over time and in response to global changes and nuclear accidents.

The prevention of proliferation through the transfer of nuclear technology and materials for use in a weapons program is governed by the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) and verified through the IAEA's technical safeguards measures.[8] Safeguards are generally considered to be effective and strong, and the technical features have been improved over time. Full-scope safeguards are not applied in the five declared nuclear weapons states, but they are implemented in many countries.[9] However, there are challenges to the safeguards regime. The foremost is from nations that are not party to the NPT, and therefore, not subject to full-scope IAEA safeguards. These countries include India, Israel, and Pakistan. North Korea was a member of the NPT and withdrew. While the NPT and the safeguards system has prevented significant proliferation of nuclear weapons, its weaknesses have been exploited by some nations, most prominently Iraq and Iran, which both pursued clandestine uranium enrichment capabilities. The global response to Iraq's challenge was the creation of the Additional Protocol, which supplements state's IAEA safeguards agreements and requires more information and stronger inspection access, but not all nations have approved it.[10]

The nuclear security regime is focused on preventing nuclear material theft from facilities, insider threats, and outside attacks including terrorism. Unlike the CNS, the nuclear security regime's key international conventions – the amended Convention on the Physical Protection of Nuclear Materials (CPPNM)[11] and the International Convention for the Suppression of Actions of Nuclear Terrorism (ICSANT)[12] – do not include provisions for mandatory assessment, information sharing, or peer review. While nuclear security has a useful peer review process conducted by the IAEA, it is intermittent, voluntary, and confidential. Also, the IAEA's primary recommendations for the physical protection of nuclear materials, INFCIRC/225, is non-binding. In 2010, the IAEA's International Nuclear Safety Group concluded that, "Nuclear power plants benefit from a sophisticated and comprehensive safety regime that has been established over the years…the security regime for nuclear power plants is far less developed than the safety regime."[13] However, since that time, the nuclear security regime has been incrementally strengthened through the NSS process – a series of heads-of-state meetings on preventing nuclear terrorism that were held from 2010-2016 – and supported by the expanding scope of the non-governmental WINS.[14]

There are a number of other regional agreements that are relevant to safety, safeguards, and security. For example, regional nuclear weapon free zone treaties have been established to further the weapons restrictions of the NPT. Multilateral (Euratom Treaty) and bilateral (Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials) systems further supplement the safeguards and nonproliferation regime. Also, export control groups, such as the Zanger Committee and Nuclear Suppliers Group (NSG), reinforce the regime with restrictions on exports to states that lack appropriate safeguards, although exceptions have been made.[15] The European Nuclear Security Regulators Association and the Asian Nuclear Safety Network are examples of a regional organization of regulators that were set up to exchange information that could provide a model for broader sharing among regulatory counterparts.

There also are several other conventions covering specific issues like the safety of spent fuel and radioactive waste management,[16] the early notification of a nuclear accident,[17] and on assistance in case of a nuclear accident or radiological emergency.[18]

One of the major strengths of the current nuclear governance system is its adaptability to new information and circumstances. For example, in the safety regime, three conventions and WANO were established within 10 years of the Chernobyl accident. INPO was created in response to the accident at Three Mile Island. More recently, the Fukushima accident led to stress tests and safety upgrades around the world. In the security regime, the terrorist attacks of 9/11 led to the adoption of ICSANT, U.N. Security Council Resolution 1540,[19] and the 2005 CPPNM Amendment. More recently, the NSS process and its gift baskets were used to spur additional actions among key states.[20] In the nonproliferation regime, India's 1974 test led to the creation of the NSG. The Iraq nuclear program led to the Additional Protocol and a strengthening of export controls. International cooperation to counter illicit nuclear trafficking has been increasing since the fall of the Soviet Union. Also, the IAEA is a stable and capable international organization, with almost universal participation, that provides in-depth technical guidance and peer review capabilities.

In the nuclear security area the system relies mainly on recommendations and voluntary implementation and lacks universal standards. Also, the Design Basis Threat differs from state to state, and there are no common security standards among states which, together with the lack of common security standards, makes the adequacy of each nation's actions difficult to measure. There are no legally-binding requirements for regular inspections or information access. There also is overlap between nuclear safety and security, without a systematic approach to de-conflicting them when problems arise.[21]

Another significant challenge is the weak enforcement system for the overall nuclear governance system. Stringent enforcement of commitments can be a disincentive for countries to sign up for new commitments, especially if they anticipate that it may impact their national economy and sovereignty. But there needs to be a better means to encourage compliance, and the IAEA, as a mainly consensus-based organization, is not well positioned to enforce commitments.

Another area of concern, in an era when many older reactors will be retiring, is the lack of specific international standards on waste and disposal issues. Guidance is provided through several

conventions, but long-term environmental and safety impacts of radioactive waste disposal are a significant issue for the public. The governance system in this area is severely lacking.

Finally, the rise of terrorist groups with the goal of creating mass casualties, including by using nuclear material or weapons, have added a new dimension to the threats that the nuclear security regime needs to address. Terrorist groups have demonstrated they are active both in traditional and more recent nuclear states. Regardless of where it occurred, a terrorist nuclear incident would have truly global consequences, all of which would have significant and negative security, political, and economic implications. The current nuclear security regime is not adequate to deal with the dynamic threats from these terrorist groups.

Adaptation of the overall nuclear governance regime is necessary as these problems continue and new challenges arise. This process of adaptation should be policy proactive and focused on building the maximal level of confidence in the nuclear enterprise around the world. This will be difficult for a number of reasons, including commercial competition and the evolving nature of nuclear suppliers. However, the overall governance regime must not be primarily reactive, as it has been in the past, as this could undermine public confidence at a time when nuclear power is rising in importance in addressing the climate change challenge.

Public Confidence and Communication

Public confidence is critical to the continued safe and secure use of nuclear power, and the strength and credibility of the nuclear governance regime is a significant contributor to the level of public trust. Most people do not actively think about the detailed technical elements of the governance regime. Instead they rely on the government officials and nuclear regulators to assess safety and security needs and responses. They also rely on media reporting and that in turn is dependent on the perspectives and analyses of various non-governmental and nuclear industry experts.

There is a public suspicion about radiation in general, and anomalous events such as major nuclear accidents, have a significant impact on public perception and tend to feed a narrative that nuclear officials and nuclear power cannot be trusted. Further complicating the situation is the fact that after every major accident, governance changes have been made in response. This leads to the question of why the system wasn't changed in advance to prevent the problem. That can undermine the credibility of government, industry, and civil society sources.

There is a need to modernize the narrative about nuclear power at a time when its role in addressing the global climate challenge is rising in importance, and the public is increasingly demanding displays of corporate social responsibility. Creating the conditions for this communication transition could involve: (1) structural changes, including analyzing the various components of the nuclear governance system and identifying how these elements can reinforce one another and create institutional strength in depth; (2) cultural changes, including more unified global safety, security, and nonproliferation culture and expanded education and training capacities, technical and non-technical; and (3) policy changes including the creation of waste repositories and decommissioning plans.

The Fukushima Legacy[22]

The Fukushima nuclear accident is an illustrative case of the importance of public confidence for nuclear energy production. The accident has resulted in a major loss of trust from the Japanese public in nuclear power, as well as in its overall energy policymaking. The Independent Diet Commission on the Fukushima Accident concluded: "The accident was preventable." It resulted from regulatory capture, poor crisis management, and a lack of trusted information sources including the Tokyo Electric Power Company (TEPCO) and the Japanese government.

Most nuclear power plants in Japan remain shut down five years after the accident, and the majority of the public thinks nuclear power should be phased out. One reason is that the poor handling of information during the crisis has undermined trust in all subsequent communications and communicators. Another is concern about the contamination in the vicinity of the accident. Radiation levels in evacuated areas differ across the prefectures. This makes it difficult for the mayors of each to make any blanket statements about safety, creating a perception of inconsistent communication. A third is that there has not been any mid-to-long-term oversight measures created for the decommissioning of Fukushima. Oversight coming from within the nuclear industry is not trusted. While the newly established Nuclear Regulatory Authority may be doing a good job of regulating the nuclear industry, TEPCO which solely manages the Fukushima site, faces significant public trust issues rooted in the insufficient transparency of its operation. As a result, according to the public polling done by the Asahi Shimbun, 57 percent of the Japanese public opposes restarting existing nuclear power plants even if they satisfied new regulatory standards.[23]

A further complication is that the uncertain future for nuclear power in Japan has highlighted concerns about the country's fuel cycle and plutonium policies. Without a large, active nuclear program to justify plutonium recycling, domestic and international worries are being raised about the potential for excess plutonium stockpiling and the implications that has for influencing proliferation in the region.

In post-Fukushima Japan, the climate arguments for preserving nuclear power have not been persuasive, despite the fact that Japan probably will not be able to meet its Paris Agreement climate commitments without a nuclear power restart. There was a brief power shortage after the Fukushima accident, but this has been followed by usage declines and improved efficiency. As a result, there has been no power shortage even without nuclear power. Initially, carbon dioxide emission increased due to increased consumption of fossil fuels, but it has dropped in the last two years. These short-term observations heavily influence the public's perception about the necessity of nuclear energy for climate change.

The Fukushima accident also had reverberations well beyond Japan and influenced the trust level in nuclear power in other nations. On an international level, Fukushima has had a significant impact but not a lasting one in all nations. The most noteworthy effect outside of Japan was Germany's decision to phase out all nuclear power. The accident caused an initial drop in public opinion on nuclear power in the United States, but it has since recovered. Similarly in Canada, support for nuclear declined but rebounded.

The Nuclear Supplier and Newcomer Evolution

While the debate about the future of nuclear power continues, the locus of new construction has shifted primarily to Asia and to some degree the Middle East. This is causing significant changes in patterns of nuclear supply and raising questions about the future application of nuclear norms and the preparedness of the nuclear newcomers to manage their infrastructure.

Rise of Non-Traditional Suppliers

Traditional nuclear suppliers, including, the United States, France, and Japan, are giving way to emerging suppliers including Russia, South Korea, and China. Many nuclear vendors are struggling in this environment, and the lack of economies of scale and reactor standardization makes it very difficult to profitably build individual reactors and plants. While the emerging suppliers are most interested in selling fleets of large-sized reactors, most of the new customer nations are interested in one or a few reactors.

Russia and China have the most active nuclear production lines, the capacity to increase manufacturing, and the state financing to support it. However, neither of these nations has been a leader in the nuclear governance area. For example, Russia's Rosatom originally was part of the creation of the Exporters' Principles of Conduct[24] but pulled out of those discussions. China was close to joining but never did. This raises questions about what the standards of the emerging exporters will be and how it will affect importers, public perceptions of nuclear power, and the global nuclear governance system.

Even if the exporters are maintaining high standards for their fleets at home, it is not clear that they will have the capacity to involve their regulators in helping recipient countries or will impose their domestic standards as a condition of supply. This could leave nuclear newcomers with a significant challenge in developing a domestic governance infrastructure and may increase the real risks of incidents.

Nuclear Newcomer Challenges

The expansion of nuclear power is currently moving in two directions. One is the expansion of reactor building in nations that already have significant infrastructure, particularly China and India. The other axis of expansion is by newcomer nuclear nations. These are nations that are building or contemplating the use of nuclear power for the first time. This includes countries in the Middle East, South East Asia, and potentially Africa.

The lead country in this group is the United Arab Emirates (UAE). The UAE has taken a very deliberate and conscientious approach to their nuclear power program, choosing to import expertise from around the world to assist with regulatory and operational development while building their core of domestic technical and regulatory expertise. In addition, in the nuclear cooperation agreement signed with the United States, the UAE agreed to forgo domestic uranium enrichment and reprocessing of spent fuel, thereby alleviating concerns about the two most important pathways to the potential for nuclear weapons. Jordan has taken the first step toward nuclear power with the construction of a research and training reactor. In preparation, it has centralized most of its nuclear management through the creation of an atomic energy and regulatory agency.[25] Other countries in the Middle East are giving various

levels of consideration to nuclear power, including Saudi Arabia, Egypt, and Morocco, all of which have taken steps to develop technical and regulatory infrastructure, signed various scoping contracts and done siting evaluations.[26]

In South East Asia, several research reactors are already operating, including in Indonesia, Thailand, and Vietnam. Not surprisingly, these are also the three nations in the region that are seriously contemplating a step up to nuclear power reactors. Indonesia is considering five reactors, and has developed a governmental infrastructure to manage its nuclear activities, including the National Nuclear Energy Agency and the Nuclear Energy Regulatory Agency.[27] Indonesia has also taken the useful steps of conducting an internal self-evaluation to determine the progress of its national competence and asking for a peer review of their preparedness from IAEA. Indonesia has been vocal about the impact that climate change is having, as it is a nation composed of many islands. Thailand also is looking at the construction of five reactors in part because of its pressing energy demands.[28] However, its pursuit of nuclear power has been constrained by domestic opposition, civil unrest, natural disasters, and economic concerns. Vietnam has been the most aggressive nation in South East Asia by considering up to ten new reactors. A nuclear cooperation agreement between the United States and Vietnam is now in force, but in the fall of 2016, the National Assembly voted to abandon the construction of the first two plants, placing in doubt its future nuclear ambitions.[29]

The newcomer nuclear nations face several common challenges. One is the depth and breadth of the nation's nuclear research and education infrastructure. In virtually all cases, this educational capacity is thin. A related issue is personnel training. The education and training of the required number of technical workers to sustain a nuclear program is a challenge in the newcomer nations in part because they are all developing economies.[30] These issues can be addressed through cooperation with the IAEA and also through assistance from nations with more advanced nuclear power programs.

But, there are other cultural, security, and political challenges in many of these nations as well. For example, there are major gaps in the adherence of nuclear newcomers to many of the key agreements, norms, and codes of conduct that comprise the international regime.[31] Many also received low scores on assessments of corruption resistance and adherence to rule of law.[32]

China's Nuclear Ambitions[33]

While nations in Asia and the Middle East are contemplating or pursuing new nuclear power, the most significant expansion of reactor building is occurring in China, followed by with India and Russia. China, with 55 reactors operating or under construction and scores more planned for in the future, is the world's emerging nuclear energy leader. This has significant implications for global nuclear governance.

From a domestic nuclear governance perspective, the IAEA has found China's regulatory process to meet international norms. China's regulatory system administrator reports to the State Council and China Nuclear Energy Agency. China has adopted a number of practices from nations with well-established nuclear programs, works in coordination with the WANO and INPO, and has responded to concerns identified by these organizations.

Regarding the security of China's nuclear plants, their facilities are protected by razor wire, cameras, and guards without guns. There is little fear of an outsider attack. For insiders, China's objective is to dissuade workers from doing anything disruptive. The people who work at the plant live in the community nearby, and they are fed, housed, and schooled there with their families. China also professes not to have cyber security fears. They employ an analog panel right next to the digital controls in case something goes wrong and they need to switch systems.

China is building many plants at once and using different technologies, and this requires the maintenance of high quality construction, strong regulatory oversight, and the development and retention of staff with appropriate training and qualifications. About 13,500 people are needed for operating plants and another 4,500 for those under construction. Its management system is hierarchical, and it has little experience with subordinate employees challenging the actions or decisions of superiors.

While an important producer of domestic power, China's nuclear industry is also gearing up to be a dominant technology supplier to other nations. China is developing small modular reactors (SMRs) and advanced, non-light water, nuclear technologies. They are considering water-based SMRs for small grid applications and have molten salt cooled and fueled and sodium reactors in the research and development (R&D) pipeline. China has built a significant nuclear industrial base, and exports are the next logical step. China General Nuclear Power Group and China National Nuclear Corporation are the two companies authorized to build nuclear plants. They are overseen by the National Nuclear Safety Authority which is under the Ministry of Environmental Protection and reports to the State Council. China's development strategy has been to buy foreign-designed plants (France, United States, and Russia), obtain licenses for the technology, and then modify the components in order to localize the content for Chinese companies. They have placed a heavy emphasis on localization and will rely on outside companies only for monitoring and control aspects.

All of this construction, operation, and R&D is positioning China to become a leading nuclear vendor for both conventional and advanced reactors. But, this situation poses a number of concerns for the nuclear governance system. It is unclear at present what China's export philosophy will be and how it will ensure vendor and regulatory oversight. Further, if China becomes an operator of a closed civil nuclear fuel cycle, it is unclear if they will seek to export reprocessing technologies abroad, raising proliferation concerns. And, of significant importance, if China becomes a dominant global nuclear supplier, it is unclear if it will uphold the existing nuclear governance system or tolerate laxer standards to promote sales in a highly competitive and challenging environment for suppliers and recipient countries.

Avoiding a Race to the Bottom

As the nuclear landscape evolves, it is critical to avoid a "race to the bottom" that undermines nuclear governance standards to promote commercial interests. In a competitive environment, suppliers may be willing to undertake risky sales to countries that lack strong credentials. This could lead to declining safety and security standards and the increasing threat of nuclear incidents. The main concerns are the adequacy of: nuclear safety and security; liability law; weapons proliferation prevention; infrastructure development; and personnel training and replacement.

The maintenance of robust and responsive nuclear governance is a global challenge that is essential for sustaining nuclear power's vital role in addressing climate change. Traditional nuclear power states also must remain engaged in international nuclear commerce to ensure nuclear governance grows more robust and responsive as nuclear power plant become more widespread globally. For the West to remain actively engaged in international nuclear commerce and to continue its ability to influence international governance, it is essential that the existing nuclear power fleet be maintained, not prematurely shutdown, and replaced after retirement.

There also is a geopolitical importance to ensuring that the United States and other Western countries remain viable nuclear suppliers. The sale of a nuclear reactor to a country entails significant economic interaction, legal obligations, technical interactions, and political influence. In an increasingly fractured and volatile international environment, developing and maintaining allies and partners through energy cooperation can promote the long-term adherence to international conventions and norms. Racing to sell or build new technologies in lax regulatory and governance environments is not a long-term strategy for sound technological advancement or the maintenance of global security.

Conclusion

Nuclear governance is in need of a reboot, and there are approaches and actions that should be taken to make the system stronger, increase its effectiveness and adaptability, and improve its resilience. The global nuclear governance system is facing a series of new challenges that require effective responses. This includes nuclear power's growth and attendant increases of facilities and materials, nuclear newcomer nations and an evolving nuclear supplier situation, and new and rapidly evolving challenges like cyber security and terrorism. To address these and other emerging concerns, a key nuclear governance concept must be "realistic continuous improvement." This will allow for the identification and proactive response to problems without unnecessarily impeding operations. There also is the need to improve the international nuclear security regime, which lags behind the safety and safeguards regimes, which also require continued strengthening.

Improvement of the nuclear governance system needs to be pursued through the institutionalization of a strong coalition among governments, the nuclear industry and its professional associations, and the nuclear nonproliferation, security and safety communities. Together this coalition can assess requirements for improvement and formulate balanced and needed advances to the system. In addition, this coalition can develop the effective and approachable communication and messaging that is required to build confidence among the public that weak links in the system are being effectively strengthened.

The evolution of the nuclear supplier landscape raises a number of new challenges to the continued maintenance and improvement of the nuclear governance system. The traditionally dominant nuclear suppliers are becoming less important in the international nuclear marketplace. They largely have been the architects of the current system, and the emerging suppliers do not have the same depth and history in developing and improving nuclear governance structures. But, the nations that dominate the

nuclear market will have significant influence over the future effectiveness of the nuclear governance system. In this environment, the traditional suppliers must maintain their influence and protect and innovate norms. Emerging suppliers must demonstrate an enduring commitment to protect these standards.

The nuclear newcomer states pose a particular challenge to the nuclear governance system for several reasons. There are political tensions in the regions where nuclear power is growing and under consideration, including North East Asia and the Middle East. The coming wave of operating nations exhibit weaker institutional strength, regulatory quality, and corruption control. Also, the next generation of advanced reactors will be smaller and likely will be more widely distributed than existing LWRs, placing an additional strain of the existing governance system and structures. Additional assistance from long-standing nuclear operating states and the IAEA is required to support these nations in preparing for their nuclear infrastructure. As well, the IAEA and all nations involved with advanced reactors need to address the governance systems that will be required to effectively cope with a multi-technology environment.

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* Ms. Hayward left the working group in January 2017 when she began a new job at the IAEA. Her contributions to the project before that time are greatly appreciated.

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