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# Acknowledgments

In 2024, the Carnegie Endowment for International Peace (CEIP) and the Pacific Northwest National Laboratory (PNNL) co-hosted a series of meetings focused on the emerging nuclear energy ecosystem, culminating in an in-person conference in Bucharest, Romania, hosted by the Romanian Ministry of Foreign Affairs and in partnership with the Nuclear Energy Agency (NEA) of the Organisation for Economic Co-operation and Development. Participants in these meetings—including experts from government, industry, and academia with backgrounds in nuclear technology, law and policy, waste management, stakeholder engagement, financing, nonproliferation, safety, and security—examined current assumptions about nuclear energy deployment, identified emerging challenges, and considered possible approaches for shaping future governance structures, practices, and behaviors. The meetings were held under the Chatham House rule, thus the thinking presented in this paper reflects the authors' insights and recommendations from these meetings and ideas spurred by subsequent developments, but not necessarily the views of the participating experts, their governments, their institutions, the Romanian Ministry of Foreign Affairs, or the NEA. Neither Carnegie nor PNNL take institutional positions on public policy issues; the views represented herein are those of the authors and not necessarily reflective of the views of PNNL or Carnegie, including Carnegie staff or its trustees.

# Introduction

Nuclear power is an increasingly sought after option for meeting energy demand at scale and around the clock. Despite significant up-front investment, once built, nuclear plants promise consistent and reliable energy at low operating costs. They are widely perceived as important contributors to energy security, economic development, and carbon emission reduction.[1]

Reflecting this enthusiasm and faced with managing surging energy needs and decarbonization goals, numerous countries, companies, and financial institutions have pledged to support a major increase in nuclear energy deployment. In May 2025, in directing significant changes in U.S. nuclear energy policy, Donald Trump's administration set an ambitious goal of increasing U.S. nuclear energy capacity fourfold from roughly 100 gigawatts today to 400 gigawatts by 2050.[2] Several major American technology companies such as Amazon, Google, Microsoft, and Meta announced plans to partner directly with nuclear energy suppliers to secure long-term power for their data centers.[3] These ambitious goals clearly demonstrate the momentum driving a significant expansion of nuclear energy and indicate not only how quickly the nuclear energy marketplace is changing but also how significantly the future nuclear ecosystem will differ from the past.

To meet global nuclear energy demands, major vendors offer a variety of technologies, ranging from very large systems (gigawatt-scale facilities) to new types of micro reactors (less than 50 megawatts). The advertised, innovative features of small modular reactors (SMRs) and advanced reactors, though still largely untested, are among the catalysts of interest in using nuclear energy for various applications—both traditional and novel, commercial and military. Some reactors of smaller size are adaptable for different-sized electrical grids, deployable closer to population centers, and suitable for alternative applications such as

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generating industrial heat and powering data centers, remote military bases, commercial ships, and space vehicles or facilities. Moreover, if any one design was deployed widely, standardization of components for the reactors could help achieve significant economies of scale that could lower deployment costs. In addition, smaller-sized reactors have advanced design features including passive safety and security systems, and they reportedly will produce lower total waste volume, all of which are seen as improvements over traditional reactors. As a result of these putative benefits and rising interest, there are more than eighty SMR designs under development around the world.[4]

Governments, nuclear industry actors, utilities, private sector nuclear energy consumers, and other actors are focused on addressing what they perceive as up-front requirements for deployment to enable a rapid and widespread implementation of nuclear energy.[5] These initiatives mostly relate to shortening the time to market for new reactors: streamlining regulations, producing adequate quantities of specialized fuels, securing essential financing, mitigating supply chain constraints and vulnerabilities, and developing the needed workforce. Resolving these issues is integral to achieving the ambitious objectives noted above and forms the primary agenda for nuclear power.

Such actions may be necessary, but they are unlikely to be sufficient. Nuclear energy has previously experienced similar periods of anticipated expansion that were then dashed by loss of public support due to accidents, cost overruns, political changes, or other problems.[6] Therefore, focusing exclusively on the near-term challenges that constitute the primary agenda does not guarantee that a significant expansion of nuclear energy will deliver all the claimed benefits for its users. To ensure those outcomes, governments and industry actors need to address a broader agenda of requirements, including building support among the general public and especially intended host communities for nuclear plants.

The broader agenda comprises medium- or even long-term issues that are tempting to defer because they may not seem to obviously stand in the way of deployment. Yet, these issues (or, in many instances, hasty or delayed decisions) will have significant and long-term implications for sustained public support and commercial interest. The main issues in this broader agenda, many of which are interconnected, include the geostrategic implications of fuel choice, the impact of technology selection on deployment scenarios and waste management, the potential for misuse or diversion of technology and materials to nuclear weapons efforts, the need for comprehensive liability frameworks, and the importance of building robust public support through authentic, consensus-based engagement. The underlying premise of the broader agenda is that nuclear energy is an atypical investment—marked by high capital intensity, technical and regulatory complexity, and intergenerational obligations—and thus

requires a more holistic and longer-term focus on the requirements for durable and sustainable deployment. Unless stakeholders also work concurrently on the broader agenda, they will be deploying on a shaky foundation that carries considerable risk for the entire nuclear energy enterprise.

## Nuclear Energy Requires Different Culture and Planning

To appreciate the types of approaches that may be needed to sustain nuclear growth, it is important that all stakeholders, regardless of their specific roles and responsibilities, understand how nuclear energy is fundamentally different from other energy sources, what a strong nuclear culture entails, and what these imply for how it should be operationalized.

The success of nuclear energy cannot only be measured by meeting deployment schedules and electricity generation objectives. Rather, it hinges on the adoption of exceptionally long time horizons, far beyond those associated with other energy sources. Notably, nuclear investments effectively constitute multigenerational commitments to pay off high up-front costs, operating times that can stretch eighty to one hundred years, and eventual decommissioning requirements.[7] Finally, nuclear waste products require careful management and robust safety measures over millennia to mitigate potential impacts on human health and the environment.

Since a permanent disposal solution has proven elusive, the main challenge associated with nuclear waste is determining where and how to store it. In most countries, interim nuclear waste storage, often at reactor sites, has become effectively indefinite without explicit public buy-in to this approach. A few countries are making progress toward permanent waste repositories, but the process of siting and constructing one is decades long.[8] This problem is likely to become more acute with spent fuel accumulation resulting from increased nuclear capacity worldwide, as well as the forthcoming decommissioning of reactors that are aging out of service.

Risk management requirements also differentiate nuclear energy from other energy sources given the multifaceted consequences stemming from a potential incident: geopolitical implications, potential loss of public and especially host community trust, long-term environmental degradation, enduring impacts on public health, and nuclear weapons proliferation. In this regard, the world awoke to a new type of risk—nuclear power plants in conflict zones—when Russia attacked Ukraine's Zaporizhzhia Nuclear Power Plant (ZNPP) in March 2022. This assault and ensuing occupation were unprecedented in the nuclear age and raised the risk of a nuclear emergency "whose effects would be felt far from the borders of Ukraine."[9]

**Although nuclear responsibilities may be stovepiped among different stakeholders, the risks and consequences are shared by all.**

The ZNPP attack also revealed how the globalization of nuclear supply chains, the enduring nature of nuclear cooperation agreements, and the transnational nature of nuclear incidents make the nuclear energy enterprise globally interconnected and interdependent. As nuclear physicist Alvin Weinberg observed shortly after the Chernobyl disaster in 1986, "a nuclear accident anywhere is an accident everywhere."[10] His reflection was acutely felt during the aftermath of the March 2011 disaster at Japan's Fukushima-Daiichi Nuclear Power Plant, which led many countries to pause their nuclear energy development programs and some, including Germany, Belgium, and Italy, to decide to phase out nuclear energy entirely. For its part, the United States invested millions in safety reviews and upgrades at existing plants to mitigate the risks the Fukushima accident revealed. Some states that opted for nuclear phaseout have since reversed course, but the shadow of a future accident hangs over the aspirations for a massive nuclear expansion.[11] What the Fukushima disaster demonstrated in a visceral way is that although nuclear responsibilities may be stovepiped among different stakeholders, the risks and consequences are shared by all.

Lastly, though there is much to learn from examples like the ones noted briefly above, history only teaches so much. There are a range of factors that could make tomorrow's nuclear landscape dramatically different in ways that add to the challenge of managing this complex technology.

# The Evolving Nuclear Ecosystem

Enthusiasm for SMRs and advanced reactors amid rising global interest in nuclear energy could potentially reshape tomorrow's nuclear landscape, driven by the unprecedented pace, scale, and diversity of nuclear development currently underway. In the rush to build as fast and as widely as possible, critical issues could be overlooked or downplayed if they are not addressed as part of a broader agenda. These critical issues tend to fall into three categories: new stakeholders, new uses, and new technologies and approaches.

## New Stakeholders

- Additional stakeholders will be involved in the nuclear energy enterprise beyond traditional roles assumed by governments, vendors, utility owner operators, or public utility commissions. These new stakeholders include major technology companies, public and private financial institutions, project developers, and supply chain partners. (There have been a raft of announcements of partnerships between technology

companies, nuclear vendors, and utilities, such as that between Amazon, X-energy, and Energy Northwest.)[12] Many of these entities face an acute need for energy and have significant financial capital, yet lack deep familiarity and experience with internationally accepted nuclear practices, standards, and norms for safety, security, nonproliferation, liability, and other requirements for stable, long-term nuclear operations.

- In some developing economies, there are likely to be new, less experienced, or capacity-constrained regulators and operators handling the licensing, construction, and operation of nuclear power plants.[13]

## New Uses

- Nuclear reactors are likely to serve a broader range of applications, from providing process heat for the chemical industry to powering data centers, mining operations, and even commercial shipping. These uses are not adequately addressed in existing legal and regulatory frameworks and international best practices. These instruments will need to be updated to account for different specifications of the reactors, divergent business and deployment models, and conditions inherent to these applications.

- Further, nuclear power systems could be deployed in many new types of locations that traditionally were not seen as practical or safe, for example, at remote sites, on barges or commercial ships, at military bases, in areas that are conflict prone, or even in space—scenarios either not covered or not sufficiently addressed by existing governance mechanisms.

## New Technologies and Approaches

- Many of the new reactor designs will utilize a range of novel fuel forms and contents. There is also growing interest in recycling nuclear fuel to extract and re-use some of its fissile content and reduce waste volumes. While some designs feature co-located recycling facilities, there is also potential for separate, privately run reprocessing facilities. This expanded fuel economy will result in additional facilities capable of producing materials usable in nuclear weapons, introducing new proliferation risks. At the same time, it will strain existing institutions responsible for facility and process monitoring and material control and accounting.

- Countries interested in expanding nuclear power may seek to participate in fuel cycle operations, whether enriching uranium to enhance energy security and economic development or reprocessing to manage irradiated fuel. Many states regard these activities as their right to peaceful nuclear energy afforded by the Treaty on the Non-Proliferation of Nuclear Weapons. Efforts by nuclear suppliers to control

these technologies are perceived as infringements on that right. It is therefore possible that additional states will develop national enrichment or reprocessing capabilities or pursue alternative arrangements to secure greater influence over fuel supply and disposition options.

- Alternative business models, including build-own-operate contracts, power purchase agreements, and behind-the-meter approaches that give customers direct control over energy generation, are likely to further disaggregate roles and responsibilities in ways that could create gaps in managing the entire life cycle of a nuclear plant.

Any one of these issues would constitute an important evolution from more traditional models of nuclear energy deployment. The combination of issues portends a highly complex and fluid environment that presents great opportunity and significant risk. To mitigate such risks, actions are needed today to ensure the conditions necessary for successful operation in 2050 and beyond.

## Engaging the Broader Agenda

Numerous guides already exist to help stakeholders navigate the dynamic, intergenerational, and interconnected aspects of nuclear energy deployment in this evolving ecosystem. Some guides comprise current standards and practices that promote commitments to nuclear safety, security, and nonproliferation, as well as transparent and inclusive decisionmaking processes. For instance, the International Atomic Energy Agency publishes guidelines for states preparing to implement nuclear energy programs.[14] Similarly, the Nuclear Energy Agency maintains reference documents that represent the cumulative experience and wisdom of leading nuclear countries.[15] The World Association of Nuclear Operators likewise provides recommendations and ongoing support for successful nuclear power plant operations.[16]

However, continued excellence in performing today's best practices is not sufficient to adequately manage evolving approaches to nuclear energy. Future success requires deliberate and collaborative efforts among stakeholders to strengthen existing guidance as part of the broader agenda, based on an understanding that nuclear power is a fifty-year investment and likely would involve a 100-year relationship with the host community. This includes:

**Transparent, Authentic Stakeholder Engagement:** Traditionally, successful alignment of stakeholder perspectives around nuclear projects has been one of the toughest challenges for decisionmakers to navigate. Many relevant organizations set high standards for safety, security, and environmental protection. However, despite common recognition of the importance of these standards, the process of creating and meeting them takes time. For example, a standard practice may be perceived to encroach on,

or clash with, a country's sovereignty, political sensitivities, commercial interests, and more immediate energy needs or development objectives. Resolving this tension could take years and result in different safety, security, and environmental protection standards being implemented in different countries. In other cases where competing interests take precedence over acceptance of standard practice, opposition from host communities could increase due to their concerns about public safety, health, and justice, which could further delay progress and undermine long-term success of these projects. The alignment of these international, national, and local perspectives requires deliberate attention to stakeholder sensitivities, needs, priorities, and interests, especially for host communities, who need reassurances about perceived risks as well as tangible benefits to accommodate nuclear power in their midst. Ideally, this process to engage stakeholders around upholding standards starts years before plant construction begins at the local level, where impact is felt for generations and where needs and priorities fluctuate more than those at the international level.[17] As new challenges and complexities arise, sustaining stakeholder support will require transparent and authentic dialogue, not simply attempts to allay concerns with economic incentives. A robust, independent, and publicly facing nuclear regulator will continue to play a central role in securing and sustaining stakeholder support in the new nuclear ecosystem, while regulators with less experience in licensing reactor designs and certifying nuclear operations would benefit hugely from the more experienced ones.

**Implementing State-of-the-Art International Standards:** Adherence to the highest international standards and core practices pertaining to safety, security, liability, and nonproliferation is a necessary condition for nuclear energy success. However, continuous adjustments and improvements to these standards to meet new conditions and lessons learned will be critical as the ecosystem evolves. At the same time, organizational silos, market competition, and geopolitical rivalries are creating fractures in the international system. These fractures are introducing higher costs for nuclear investors and have the potential to create new nuclear safety, security, and proliferation risks. To mitigate these fractures and risks, it may be helpful to standardize (to the extent possible) supply chain elements for similar reactor designs; harmonize (to the extent practical) legal and regulatory frameworks; collaborate with like-minded states, regional neighbors, or even business competitors; share lessons learned and insights from operating experience; and create comprehensive guidelines that include new risk mitigation practices, technologies, and approaches. Amid these adjustments, it is important to retain openness to how the distinct nuclear cultures of individual states and their associated industries inform the implementation of international standards. These adjustments to existing standards and practices could reap desired economies of scale, close governance gaps, and further strengthen the foundation underlying the future nuclear ecosystem.

**Commitment to Nonproliferation:** International safeguards and security-by-design, complemented by responsible handling of nuclear exports, serve critical functions in mitigating proliferation risks associated with civil nuclear expansion. They are

also good business practices in terms of attenuating potential sources of liability, protecting intellectual property, and promoting technological competitiveness. The variety of new reactor designs currently under consideration, the inherently dual-use nature of nuclear technology, the growing demand for enriched nuclear fuel (including so-called high-assay low-enriched uranium, or HALEU, that will be utilized in some new designs), and the potential for broader adoption of spent fuel recycling will create new safety, security, and safeguards implementation challenges. Collaboration among public and private stakeholders will be needed to strike a new balance between making nuclear technology broadly available and preventing proliferation. In this regard, adopting new technical solutions and establishing collective approaches to transparency in ways that promote and demonstrate a commitment to peaceful uses of nuclear technology will be essential.

In addition to the augmentation and evolution of well-established practices, the broader agenda also requires stakeholders to consider new issues and approaches to address challenges that are starting to emerge on the horizon.

**A New Look at Liability:** The existing nuclear liability regime aims to encourage the establishment of a sufficient pool of resources to compensate victims in the unlikely case of a nuclear incident, to channel responsibility to the operator, and to limit damages. This approach is unlikely to suffice in the evolving nuclear ecosystem. The new designs, deployment locations, applications, stakeholders, and prospective massive expansions of nuclear facilities described in this paper are but a few of the developments that call for new approaches for managing nuclear liability. Russia's 2022 occupation of Ukraine's civilian nuclear power plant presents a useful example for consideration. International humanitarian law prohibits attacks on nuclear plants.[18] However, interpretation and enforcement of these laws can vary, with little clarity about liability in such instances. Decisionmakers may need to adjust liability ceilings, as well as expectations about stakeholder roles and responsibilities as currently defined in existing liability conventions and complementary national legislations. The objectives should be to fully reflect contemporary public safety, security, and environmental considerations; provide adequate levels of compensation for all affected individuals, groups, and entities; channel clear responsibility for extending compensation; and address not merely damages but also remediation expenses.

**Broadening Fuel Supply:** The international market for nuclear fuel is becoming segmented, with Western countries seeking to phase out imports of Russian fuel and increase their own supply capacities. Although there is little concern broadly about the availability of uranium supply in the near term, this segmentation is likely to produce distortions in the nuclear fuel market just as demand is projected to rise significantly. Concurrently, enrichment suppliers and reactor vendors are wrestling with a "chicken and egg" problem regarding HALEU fuel. This specialized fuel could be utilized in some small and advanced reactors—and indeed is critical to their economic viability—but because these reactors are not yet being built, both state-backed and private

enrichment services suppliers are not yet willing to risk building new capacity to produce HALEU. Governments have begun to offer incentives for fuel suppliers to produce this fuel, but thus far it is not clear what the scale of the market will be

These potential changes in the form and content of nuclear fuels, of which HALEU is a leading example, also spur a need to assess broader safety, security, and proliferation implications. Rules for handling these new fuels may need to be adjusted from the baseline approach for regular low-enriched uranium fuel. Broadening the fuel supply to meet projected demand will require balancing multiple objectives, some of which are in tension with each other: competing domestically and internationally, including among Western suppliers; reducing reliance on Russian supply; increasing energy security; securing agreement with competitors on best practices for handling new fuels; and meeting the needs of diverse reactor customers.

**Spent Fuel and Waste Management Revisited:** There are several emerging challenges associated with spent nuclear fuel and high-level radioactive waste management. The traditional challenge remains that few communities are interested in hosting nuclear waste repositories. As waste and spent fuel inventories increase, and existing interim storage sites fill up, pressure will grow on some key stakeholders (especially governments) to implement viable, affordable, and durable strategies for minimizing the generation of spent fuel and waste and managing the accumulation and disposition of both. This is bound to create tension over the ownership of the spent fuel, given sharply differing standards and approaches around the world.

This tension may be exacerbated by the possible, eventual shortage of reliable and low-cost uranium supplies and political obstacles to building geological repositories, which may incentivize spent nuclear fuel recycling. Although recycling can reduce the volume of spent fuel, significant amounts of high-level radioactive waste will still need to be stored in long-term disposal facilities. For smaller countries that do not have large, unpopulated, geologically suitable expanses of land suitable for repositories, there may not be a feasible national solution to spent fuel and waste management. Although incredibly complicated, building regional or multinational facilities may prove a more viable approach. Even Russia, which enjoys significant commercial advantages by being able to offer both nuclear power plants and long-term fuel supply and takeback services for its foreign customers, will at some point have to confront the growing legacy of this approach.[19]

**Preparing for Military Uses of Nuclear Power:** Militaries, like other sectors, also perceive a growing need for compact, reliable, and enduring sources of energy to power military bases and facilities or to support combat. Yet, the use of nuclear power by militaries may increase the potential for operating nuclear plants in conflict zones. It is thus imperative to consider the deployment locations and risks associated with military use of nuclear energy systems, to explore new norms, and to introduce additional measures to mitigate risks. These might include safety and security features

to contain possible leaks, quick and efficient shutdown procedures, and adequate redundancy in cooling. Additional implications flow from the possibility that other, future nonproscribed military applications of nuclear energy will spread beyond nuclear-armed states, not least for naval and space applications. These will require special arrangements for ascertaining that these applications, which are not subject to standard safeguards arrangements, will not constitute a pathway to nuclear weapons acquisition.

World events, changing economic conditions, and emerging actors are constantly spurring updates to or the elimination of outdated practices, resulting in new ones that meet the needs of the moment. This process is already playing out in the new nuclear ecosystem. The primary nuclear energy agenda is forcing a reexamination of existing norms, standards, and business models in relation to future energy requirements. The broader agenda emphasizes, however, that in addition to calibrating and adapting the good practices developed over decades, there is need to consider additional approaches to ensure that future deployment is successful across generations. At the same time, it is important to consider how some of these changes and associated lessons learned might facilitate targeted easing of requirements, thereby facilitating broader—but no less safe and secure—expansion of nuclear energy.

## Recommendations

How stakeholders engage the broader agenda will have important implications for the stability, durability, and commercial viability of nuclear energy. Traditionally, competitive markets compel organizations to operate independently to advance their own bottom lines. Countries often prioritize sovereign interests when developing resources to meet national needs. To sustainably meet ambitious nuclear expansion goals, however, more cooperative approaches are required among governments, between public and private sector stakeholders, and between national and local officials and commercial entities. Ultimately, the broader agenda requires an elevated notion of self-interest and an expanded understanding of the impacts that decisions and investments will have on the nuclear ecosystem as a whole over the long term.

**Ultimately, the broader agenda requires an elevated notion of self-interest and an expanded understanding of the impacts that decisions and investments will have on the nuclear ecosystem as a whole over the long term.**

The new nuclear ecosystem will involve more stakeholders than traditionally has been the case, and thus more widely distributed roles and responsibilities. These are also likely to evolve over time as new business models take hold, the nuclear buildup takes off, and the decommissioning of aging nuclear power plants increases. It is likely that divergent perceptions among stakeholders about those roles and responsibilities could result in implementation gaps that

accrue with long-term risks. For example, given growing private sector influence, some actors may advocate for significant changes to governmental roles in nuclear energy deployment, envisioning more support yet less intervention and oversight. However, not all governments will be content with investing more while having less influence over implementation. There is also potential for divergent perspectives between national, state, and local governments, some of which might be directly affected by the new nuclear division of labor. It is unclear which stakeholders would assume responsibilities devolved by governmental agencies and ensure that all the relevant standards continue to be met.

While adjusting roles and responsibilities to accommodate changes in the ecosystem, relevant stakeholders should prioritize the following steps.

## Promulgating International Standards and Best Practices

*States should work with the International Atomic Energy Agency (IAEA), the Nuclear Energy Agency (NEA), the World Association for Nuclear Operators (WANO), and other international entities to promulgate high standards and practices for nuclear use while also seeking efficiency and effectiveness.*

- States and international organizations should reiterate their commitment to making the benefits of nuclear technology accessible widely and equitably and make that commitment the foundation of their export practices.

- States could advance criteria for license approvals, access to advanced technology, and financing based on adherence to internationally recognized standards of safety, transparency, and nonproliferation.

- Given growing potential for military use of nuclear energy, states should utilize appropriate international forums to develop and implement relevant understandings, norms, and principles for the responsible nonproscribed military applications using nuclear technology.

- Public, private, and multilateral financial institutions should develop and utilize a transparent set of criteria pertaining to responsible practices that will contribute to long-term nuclear energy success in determining whether to support projects.

- Vendors, project developers, supply chain firms, and private sector company investors in nuclear energy should commit to implementing strong, uniform international practices and to continuously improving those practices, both as best corporate practice and to level the playing field.

## Establishing Regional Partnerships

*Neighboring states should look for opportunities to reduce costs and distribute risks through collaborative or harmonized regional activities.*

- Regional groupings of states should explore nuclear-related long-term collaborations in areas such as fuel fabrication or waste management to share costs, distribute risks, and reassure their neighbors as well as the broader international community that nuclear deployment can effectively contribute to regional security, energy security, and economic development objectives.

- State authorities could codevelop and perform joint regulatory reviews to facilitate the deployment and export of advanced nuclear systems, technologies, and components in their regions.

- Regional partners, particularly those with limited resources, may see benefits from joint workforce development and supply chain management, as well as nonproliferation reassurance regimes such as the one that has been successfully implemented between Argentina and Brazil (known as ABACC).[20]

- Neighboring states could partner with the IAEA in establishing new regional technical support roles to provide technical advice and backstopping and to perform on-site inspections. These mechanisms could enable the IAEA to gain efficiency and strengthen its core competencies in performing assessments and implementing safeguards as part of its "trust but verify" philosophy.

## Thinking Locally

*Energy investors should adopt strategies for building long-term trust in nuclear energy through local actions, partnerships, and investments.*

- Rather than deferring issues pertaining to spent fuel and waste management, governments, regulators, and industry actors should begin planning with those challenges in mind and work backward through questions pertaining to recycling, reactor design, and uranium usage to inspire nuclear plant and fuel choices that will be aligned with local capabilities and requirements.

- Energy investors and other industries (such as technology and manufacturing) should join forces to enhance the benefits local communities could derive from hosting nuclear power plants, other nuclear-related facilities, localized supply chains, and colocated industrial operations.

- Nuclear stakeholders should pursue collaborative partnerships comprising investors, technology companies, scientific leaders, and members of the media to develop transparent, objective, and scientifically based communication tools to inform the public about the future role nuclear energy might play in their communities and how nuclear projects align with community goals and priorities.

- Vendors, developers, financiers, and nuclear power customers should invest in long-term, trust-based local infrastructure and capacity building to create sustained host community support.

- Public-private partnerships should reinforce responsible behavior, for example, with host community nongovernmental organizations or industry standards councils.

## Engaging Industry

*Industry should embrace a leadership role in setting a high bar for sustainable operations that protects their nuclear investments while addressing the requirements of the broader public.*

- Recognizing that there are stronger incentives to self-police when credibility is at stake, industry actors should promote business models, standards, and codes of conduct tied to safety, security, and sustainability outcomes.

- Governments should leverage their backing for nuclear energy to incentivize industry championship of nuclear best practices as part of developing new, comprehensive frameworks adjudicating roles and responsibilities for nuclear projects.

- Industry may benefit from developing and implementing these standards in ways that are harmonized across industry to manage risks, including reputational risk.[21] In this regard, user conferences of stakeholders organized by specific reactor types would be essential for sharing development and operating experience and informing future design work.

- Government and industry actors could jointly engage with prospective host communities early through site visits, polls, educational initiatives like scholarships and training programs, and other low-cost tools that build trust.

- Governments and private sector stakeholders should create task forces to study the adjustment of export policies to make it easier to accommodate growing domestic and international interest in nuclear power.

It is incumbent on all stakeholders to establish a clear and comprehensive division of labor and responsibility, in shaping the practices and behaviors needed to sustain them and developing the incentive structures that will encourage their adoption. Doing so advances the bottom line as well as the broader agenda.

In the United States, current discussions on nuclear energy incentives focus heavily on subsidizing first-of-a-kind nuclear reactor projects to create economies of scale and drive down costs; easing community outreach and transparency requirements; expediting licensing reviews and processes to facilitate exports; and prioritizing reprocessing of spent fuel and high-level waste disposition. The broader agenda requires the development of additional incentives that encourage early adoption of practices that might otherwise be delayed and that promote long-term sustainability over short-term gains.

Such incentives could include political, financial, regulatory, technological, social, and environmental options that take a different approach to traditional practices or manifest the elevated notion of self-interest espoused earlier in this paper. They should be multidimensional and work across global, national, state, and local levels to encourage adoption and sustainability. They should also take into consideration the broader impact that decisions and investments will have on the nuclear ecosystem over the long term. While further research is needed on the precise nature and structure of the incentives themselves, the most effective ones will encourage adoption of sustainability practices that become intrinsic features of near-term nuclear energy projects.

# Conclusion

The broader agenda for nuclear power discussed in this paper offers a forward-looking, comprehensive approach and specific recommendations for pursuing responsible nuclear deployment globally. The goal of presenting this broader agenda is to spur critical conversation among policymakers, established nuclear energy companies, new vendors of advanced technologies, traditional utility operators, technology companies, and other industry actors who are newly part of or seeking to join the nuclear community. It is incumbent on all these stakeholders, as well as national leaders, state authorities, international organizations, and impacted communities, to define their roles and responsibilities in this system, identify areas of mutual need and benefit, understand their interdependencies, and use that knowledge to craft effective, sustainable, and responsible incentive packages. We hope readers will consider ways to advance the broader agenda both as individual entities and via collaborative partnerships in ways that maintain and advance the high standards necessary for securing long-term nuclear energy security.

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# Notes

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