NUCLEAR INNOVATION ALLIANCE

January 14, 2021

IN RE: NOTICE OF REQUEST FOR INFORMATION (RFI) ON ENERGY SECTOR SUPPLY CHAIN REVIEW, DOE-HQ-2021-0020, 86 FED. REG. 67,695 (NOV. 29, 2021)

COMMENTS PROVIDING INPUT TO DEPARTMENT OF ENERGY'S DEVELOPMENT OF SUPPLY CHAINS FOR THE ENERGY SECTOR INDUSTRIAL BASE, INCLUDING THE ADVANCED NUCLEAR ENERGY SUPPLY CHAIN

The Nuclear Innovation Alliance (NIA) strongly supports the Department of Energy's efforts to build resilient supply chains for the energy sector. American advanced nuclear energy, supported by domestic innovation and public investment, is poised to offer new clean energy solutions to reduce global emissions during the next several decades. Domestic advanced nuclear reactor projects have begun Nuclear Regulatory Commission (NRC) licensing activities with multiple commercial advanced reactor demonstration projects completed by 2030. However, successful deployment of advanced reactors to meet U.S. climate goals of net zero emissions by 2050 depends on a robust supply chain and integrated nuclear energy sector industrial base. DOE's efforts can build the foundation for American leadership in advanced nuclear energy, creating jobs and exports through a strong domestic industrial base.

The Nuclear Innovation Alliance (NIA) is a non-profit think tank working to enable nuclear power as a global solution to mitigate climate change. We are dedicated to promoting innovation in nuclear energy technologies and business models to increase the affordability and availability of nuclear energy as a tool for addressing critical global environmental and development needs. In collaboration with other non-governmental organizations, academic institutions, private sector innovators, and other stakeholders, we work to inform innovation strategies, like that proposed by the Department, across federal agencies.

Advanced reactors are a clean energy technology that represents the fourth generation of commercial nuclear power technology. Whereas previous commercial reactors were primarily large (1,000+ megawatt electric) light-water reactors, advanced reactors feature multiple different fuel cycles and coolants, from sizes below 10 megawatts to greater than 1,000 megawatts. Detailed information about American advanced reactor innovators and technologies can be found in NIA's "Advanced Nuclear Reactor Technology: A Primer."[1] U.S. companies, utilizing public-private partnerships, are starting multiple demonstration projects that represent the first step in commercializing advanced reactors. In 2021, NIA and the Partnership for Global Security also published the "U.S. Advanced Nuclear Energy Strategy," which had many recommendations for how industry, government, and civil society could rapidly develop and deploy advanced reactors for deep decarbonization. As the Department considers the future of nuclear energy supply chains, we suggest that they review the strategy to understand how supply chain issues fit into the broader outlook for the sector.[2]

Robust, diversified, and fair supply chains are essential to the success of American leadership in next generation nuclear energy. The domestic supply chain and nuclear energy industrial base for new nuclear reactor projects have atrophied in the past several decades due to

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[1] https://nuclearinnovationalliance.org/advanced-nuclear-reactor-technology-primer
[2] https://nuclearinnovationalliance.org/us-advanced-nuclear-energy-strategy

the small number of new reactor construction projects. Although there are still some domestic suppliers, many market participants are multi-national corporations who often have manufacturing and related facilities outside of the United States. Near-term scale-up of the supply chain will require the United States to rely extensively on importing materials, components, sub-systems, and even trained personnel to make up for our current national deficiencies. Critically, some key parts of the supply chain (e.g., supply of high-assay low enriched uranium) will rely on U.S. nuclear energy trade competitors such as Russia. Given broader competitive pressures, this type of international overreliance is a potential supply chain vulnerability for the future viability of the advanced nuclear energy industry.

Over time, we expect that more domestic reactor projects will lead to onshoring of the nuclear supply chain, but a comprehensive strategy is needed from the Department of Energy to guide this process. To establish leadership in advanced reactors, the U.S. needs a strategy that best integrates trade with allied nations while also reestablishing domestic suppliers. Beyond readily apparent things like manufacturing and component supply chains, such a strategy must also necessarily include workforce development and environmental justice considerations to establish a sustainable nuclear energy industrial base that equitably meets the needs of workers and communities.

Again, we strongly support and thank the Department of Energy for its efforts to build resilient supply chains for the energy sector, including for advanced nuclear energy. As our comments highlight, advanced nuclear energy is a clean technology, it has significant export opportunities, and must be a central component of 21st century U.S. leadership. Concerted government action is needed to maximize trade and deliver high-paying domestic jobs. The following pages provide specific responses to the questions in DOE's RFI.

Thanks for your consideration,

Judi Greenwald and Alex Gilbert, on behalf of the Nuclear Innovation Alliance

Beyond these general comments, NIA offers the following specific responses to DOE's request for public comments with a focus on advanced reactors:

"Area 1: Crosscutting Topics Relating to the Energy Sector Industrial Base

The concept of the "energy sector industrial base" as a defined group of critical industry partners does not currently exist in the same way that it does for the Defense Industrial Base. The one-year reports responding to Executive Order 14017 present an opportunity to define the energy sector industrial base.

This section targets crosscutting/technology neutral input; for technology specific comments, please respond in the respective technology in Area 2 to Area 13.

1. How would you define the energy sector industrial base? For the purposes of informing comprehensive supply chain policies—including promoting supply chain resilience—what entities are included or not included in the energy sector industrial base?"

The energy sector industrial base consists of the firms, universities, federal agencies and assets, and individuals that together constitute the ability of the United States to comprehensively deliver energy infrastructure projects that meet energy goods and services needs. In many instances, the energy industrial base goes beyond just the energy sector and includes the broader physical and social infrastructure that supports and is tied to the energy industry. This can range from general construction components, such as steel and concrete, to specialized expertise such as regulatory and management consulting.

Beyond the business sector, the industrial base also includes elements of civil society that shape energy decision making and provide non-material inputs into the energy sector. Universities, trade schools, and other educational approaches are central inputs to the energy sector industrial base as they provide the necessary workforce.

"2. For adoption of clean energy technologies in the United States, what are the crosscutting vulnerabilities and gaps in the supply chain and manufacturing capabilities given the likely ramp-up in demand for these technologies?"

Broadly, the United States faces major challenges in siting and building new infrastructure, particularly at scale. While in many instances we can rely on foreign supply chains for provision of raw materials and manufactured goods, the U.S. currently lacks enough capability to provide project management for many large energy infrastructure projects. Further, as revealed by the COVID-19 supply chain crisis, we are overly dependent on foreign factories and other manufacturing capabilities for many of the basic and complex components for building new energy systems. Disruptions arising from "just-in-time" supply chain practices tied to overseas production delays U.S. energy projects, raises costs, and creates significant customer uncertainty. In scenarios where there are significant increases in demand for new energy infrastructure, the U.S. is likely to face workforce size and capability deficits.

"3. What are opportunities to expand domestic energy-related manufacturing in the United States? What conditions will lead manufacturers to reshore or expand domestic clean energy manufacturing?"

In many instances, the primary reason that manufacturers of many of the complex inputs to energy infrastructure have gone overseas is not necessarily cost (though that is important) but rather a lack of consistent, robust demand for new clean energy technologies. The boom-and-bust cycle seen in the wind and solar energy industries is a good example of this as it introduces significant investment uncertainty that undermines any plans to reshore or expand domestic manufacturing. Dramatically growing and sustained demand is an essential anchor for onshoring manufacturing for the future. Further, cost innovations and enforcement of global fair-trade rules against trade violators like China are essential to establishing domestic cost competitiveness, and to creating export opportunities. Next generation manufacturing techniques like robotics, artificial intelligence, and additive manufacturing can provide the needed innovations but greater support is needed to transfer them from Department of Energy and university laboratories into the private sector.

"4. How can the government partner with the private sector and communities to build domestic energy manufacturing capabilities? What investments and other policy mechanisms are needed to enable these partnerships?"

The federal government can help catalyze establishment of domestic energy manufacturing capabilities by creating fair global markets, providing incentives for local projects, and ensuring community input and benefit from new facilities. American manufacturers have been disadvantaged for too long by unfair trade practices that violate World Trade Organization (WTO) rules and are subject to less strict standards of environmental and social governance. International pressure for fairer competition is a prerequisite for expanded domestic investment. Local projects need some level of certainty of domestic demand and this demand signal can be challenging for certain types of projects like rare earth material processing or uranium enrichment. Through smart incentives, targeted federal procurement policies, public-private partnerships, and other financial mechanisms, the federal government can incentivize private sector investment into new capabilities. Finally, the government has a key role to play in establishing social license to operate and should work to empower local communities so that they can benefit from and support new projects.

"5. How can policies and programs that support domestic energy manufacturing also support workforce opportunities and the creation of competitive, long-term manufacturing careers, especially for communities impacted by energy transition?"

Energy systems of the future will require workers with diverse professional backgrounds, from welders, pipefitters, and other trades, to engineers, businesspeople, and administration. New programs, such as public-private partnerships, can include provisions and objectives related to workforce development and community benefits.

"Area 7: Nuclear Energy Technology

1. What are the current and future supply chain vulnerabilities as we continue operation of existing commercial nuclear reactors and accelerate the deployment of new reactor technologies? Of these vulnerabilities, which are the most crucial for the U.S. to address and focus on and why?"

The U.S. faces three specific supply chain vulnerabilities to the deployment of new reactor technologies: supply of high-assay low enriched uranium, supply of specialized nuclear facility parts and components, and supply of a trained, experienced, and workforce.

High-assay low enriched uranium (HALEU) is uranium that is enriched to a level between 5 and 19.99 percent uranium-235. HALEU is an important fuel for many advanced reactor designs and the U.S. does not currently have an established domestic supply for HALEU. Current leaders in the advanced reactor space may be forced to turn to Russia to for HALEU supply, creating a major supply chain vulnerability. Although the Department has ongoing efforts to address HALEU supply chain challenges, it is likely the most critical aspect to consider in any strategy regarding U.S. advanced nuclear energy supply chains and the U.S. is currently not yet on the path for success.

The U.S. has also lost much of the specialized businesses and workforce needed to produce high-quality and cost-competitive specialized components for nuclear reactors. In many cases, regulatory and quality assurance program requirements limit the potential vendors to a small number of domestic suppliers. Without reinvestment and onshoring, future advanced reactor development will rely on foreign supply for nuclear reactor grade parts and materials, especially for large components such as reactor vessels. Although these markets are somewhat diversified globally, in the absence of a sufficiently robust domestic capabilities, a global resurgence in nuclear power plant construction could limit availability of these key components in U.S markets. Reestablishing the domestic supply chain for nuclear parts and manufactured components is essential to the successful development of advanced nuclear energy in the United States.

Finally, even though we are only at the early stages of advanced reactor commercial demonstration projects, there are already emergent issues related to having a sufficient nuclear energy workforce. Companies are in fierce competition for engineers and other nuclear energy professionals and, in some cases, are recruiting directly from federal workforces such as the national laboratories and the Nuclear Regulatory Commission. If the U.S. advanced reactor sector scales as needed to meet the climate challenge, there will need to be many more engineers and nuclear energy professionals to meet future demands. Relatedly, although current advanced reactor projects have just started licensing processes, we expect that there will be future competition with other energy sectors for skilled trades workers in the future. Ensuring a sufficiently sized and trained workforce to meet the construction needs of both the nuclear energy and other energy sectors is essential to ensuring that spiraling labor costs and dwindling labor supply do not delay projects.

"2. Where in the supply chain does it make sense for the U.S. to focus and prioritize its efforts both in the short-term and long-term, and why? Where in the supply chain do you see opportunities for the U.S. to build domestic capabilities of nuclear energy technology manufacturing? What areas of the supply chain should the U.S. not prioritize for attraction or expansion of domestic manufacturing capabilities, and why? For areas in the supply chain where opportunities to build domestic manufacturing capabilities are limited, which foreign countries or regions should the U.S. government prioritize for engagement to strengthen/build reliable partnerships, and what actions should the government take to help ensure resilience in these areas of the supply chain?"

Establishing a domestic supply of HALEU is the highest short-term and long-term priority to ensure secure supply chains for the advanced reactor industry. Currently, HALEU supply is in a challenging chicken-and-egg scenario: there is not enough reliable demand from new advanced reactor projects to support private investment in new HALEU production capacity but without sufficient HALEU production capacity, advanced reactors developers will not have fuel availability assurances needed for new advanced reactor projects. Relying on Russian supply of HALEU for initial demonstration reactor fuel is a major risk due to potential geopolitical- related delays and continued reliance on Russian HALEU for future industry scale-up could threaten the success of many vendors in the industry by increasing fuel cycle uncertainty. Beyond the enrichment facilities needed for HALEU itself, the U.S. should also look at infrastructure needed for different types of fuel fabrication, as well as relatively minor HALEU transportation considerations.

In terms of parts and components, U.S. government action can certainly support innovation and onshoring for a new supply chain. Creating sustained demand from multiple types for reactor designs is central to providing enough incentives for a diverse set of companies that can deliver high-quality supplies at reasonable prices through broad competition. Given the current size of the nuclear sector, any policies must avoid creating monopolies or oligopolies in the supply chain as these can greatly increase cost and undermine domestic competitiveness. Moreover, other approaches such as supporting modernization of regulatory requirements and quality assurance standards can enable the nuclear sector to utilize other existing non-nuclear domestic supply chains more effectively for certain parts and components.

Generally, if the U.S. needs to turn to foreign countries or regions to make up for short-term or long-term supply chain deficiencies, it should focus on our allies and long-term trade partners. These include but are not limited to South Korea, France, Canada, the United Kingdom, and Japan. Notably, the U.S. does not necessarily need to prioritize the mining of raw uranium to ensure sufficient uranium supplies in the future. Our close trading partners Canada and Australia are world leading suppliers of raw uranium, including to the U.S. In the future, there may be environmental and social governance concerns for certain suppliers of raw uranium, like Russia or Kazakhstan, but general industry consensus is that these do not currently represent high supply chain disruption risks.

"3. What challenges limit the U.S.'s ability to realize these opportunities to build the domestic nuclear energy technology supply chain? What conditions are needed to help incentivize companies involved in the nuclear energy technology supply chain to build and expand domestic manufacturing capabilities?"

In February 2021, NIA and the Partnership for Global Security (PGS) made recommendations for a whole-of-society and whole-of government approach to creating the conditions for success for advanced nuclear energy play a major role as a climate solution. Enormous progress has been made via Congressional and executive branch leadership on specific accomplishments, but there is substantial unfinished business. In particular, the U.S. needs to articulate and implement a clearer and more comprehensive government agenda for renewing U.S. leadership in nuclear energy. If there is one thing that the Department must prioritize to promote investment, it is strong and unequivocal support for American nuclear energy. Not only must such a statement be public facing, it also needs to be directed internally to signify that nuclear energy should be a continuing priority for decarbonization and other energy sector benefits. In recent years, government support for advanced reactors, led by Congressional legislation, has led to the Advanced Reactor Demonstration Program, and other efforts to develop and commercialize advanced reactors. The Nuclear Energy Office and Loan Programs Office have become important champions for advanced nuclear energy. However, at the highest levels of DOE or across DOE offices, it is not clear that advanced nuclear energy is being given the priority and attention it needs and deserves as a climate solution. The private sector, including multi-national corporations that have choices of where they can invest, must believe that the United States is committed to building a nuclear energy future to fight climate change, and that belief must start with the Department. Per the recommendations in the joint NIA-PGS strategy, DOE should:

- Fund multiple demonstration projects with a diversity of designs to ensure American companies lead in the race towards commercialization
- Offer government testing platforms and services for industry, including the Versatile Test Reactor, Gateway for Advanced Nuclear Innovation, and National Reactor Innovation Center
- Provide appropriate incentives for first-of-a-kind nuclear plants, including loan guarantees and long-term power purchase agreements
- Maintain robust basic R&D funding
- Provide support for university research and workforce development
- Ensure that nuclear technology R&D, demonstration, and commercialization efforts at DOE are predictable, sustained, technology-inclusive, and competitive
- Support industry-competed awards through the entire cycle of technology development, licensing, and demonstration to enhance chances for successful commercialization

- Implement flexible milestone payment model options for demonstration projects to maximize chances of successful development and minimize risks to taxpayers
- Conduct analysis and applied research on how advanced reactors can supply non-electric sectors to meet deep decarbonization requirements
- Provide a clear vision for the requirements of advanced reactor fuel cycles
- Support programs that provide affordable and sufficient supplies of HALEU and support the development and/or expansion of commercial capabilities
- Pursue other action to support other fuel materials and types as needed
- Address the impacts of uranium mining in consultation with local communities
- Support development of multiple interim storage facilities to consolidate spent fuel storage
- Consider new approaches to fuel fabrication and fuel recycling using advanced technologies to reduce waste and potentially provide more economic fuel supply
- Empower NNSA and other export control agencies with knowledge about the specific characteristics of advanced nuclear technologies

"4. How can government help the private sector and communities involved in nuclear energy technology manufacturing build and expand domestic manufacturing? What investment and policy actions are needed to support onshoring the nuclear energy supply chain?"

The government, in consultation with the private sector, should conduct an in-depth study of the full extent of the supply chain required to build an advanced reactor, from metals required for steel for bolts and reactor vessels to uranium mining, enrichment, and fuel fabrication requirements. Given the atrophied state of the sector, a comprehensive assessment that can map and identify the entire supply chain is essential to enable mid- and long-term planning for future efforts to reestablish a domestic supply chain. In effect, while we know that the supply chain is weakened, we currently will not know what the critical gaps are until reactor orders start coming in. In many instances, we can fill these gaps in the short term, but early identification of gaps by the government can enable private sector innovators, including those outside the nuclear sector, to step up and fill these gaps.

Beyond this study, the government should pursue targeted industrial policy such as tax credits, procurement preferences, regulatory information support, and community engagement.

"5. What specific skills are needed for the workforce to support the nuclear energy technology supply chain? Of those skills, which ones are lacking in current education/training programs? What resources (including time) and structures would be needed to train the nuclear energy technology workforce? What worker groups, secondary education facilities, and other stakeholders could be valuable partners in these training activities? What new education programs should be included (developed?) to prepare the workforce?"

There are two general workforces relevant for the nuclear industry: engineers and related professionals, and general trades workforces.

Although it has rebounded in recent years, the number of nuclear engineers coming out of U.S. undergraduate and graduate programs is relatively flat. Other relevant disciplines, such as mechanical or systems engineers remain strong but are not necessarily entering the nuclear industry at the needed scale. The overall engineering workforce focused on nuclear energy is already struggling to meet demands from reactor designers, the regulator, and the national laboratories. If there is a significant expansion and scaling up of advanced reactors, there may be insufficient workforce to meet the additional needs of utilities and other customers developing projects, as well as related professions throughout the growing supply chain. During the first major build of nuclear energy in the 1960s and 1970s, a lack of trained and experienced personnel was a key factor behind nuclear reactor cost escalation and overruns. The Department should thoroughly investigate future expectations regarding the engineering workforce for nuclear energy, the overall academic environment in the U.S., and plans to meet a surge in demand for relevant engineering professionals. Such plans should necessarily include attracting engineers, innovators, and other entrepreneurs from other countries, as bringing the best global talent into the U.S. industry will revitalize it.

General trades professions are critical to the success of the nuclear industry, particularly for construction of new reactors. In many instances, the needs here resemble that of other clean energy sectors and the economy more broadly. Some specific programs targeted towards "nuclear innovation clusters," such as those around national laboratories and early demonstration projects can look to build nuclear construction experience for existing trades workers (as well as community college education).

In general, the commercial nuclear energy sector benefits greatly from the expertise and experience of Nuclear Navy veterans who compose a large share of the nuclear energy workforce, particularly as nuclear plant operators. Looking forward, Department efforts can work to increase the share of veterans exiting the Nuclear Navy that head to the commercial nuclear energy sector. Most of these personnel are trained as reactor operators or for closely related purposes like electricians. Beyond serving as operators for future advanced reactors, targeted programs can open opportunities for these veterans to assist with construction as well as O&M projects for new reactors.

"6. What other input should the federal government be aware of to support a resilient supply chain of this technology?"

In general, government efforts should not just focus on technological development. They should be organized around a DOE advanced nuclear energy strategy that focuses on developing competitive vendor markets, diversified supply chains, empowered workers, engaged communities, and scalable business models.