February 14, 2022

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U.S. Department of Energy

Submitted via: rfi-haleu@hq.doe.gov

Subject: Response to the Request for Information Regarding the Establishment of a Program to Support the Availability of High-Assay Low-Enriched Uranium

On behalf of the nuclear energy industry, the Nuclear Energy Institute (NEI)\(^1\) is pleased to submit the attached comments to the Department of Energy’s (DOE) Request for Information (RFI) regarding the establishment of a program to support the availability of High-Assay Low-Enriched Uranium (HALEU) for civilian use. In 2020, the DOE made two awards under the Advanced Reactor Demonstration Program (ARDP) demonstration pathway, five awards under the risk reduction pathway, and three under the ARC-20 program. Most of these designs will require HALEU and fuel forms very different from those manufactured for the current light water reactors (LWRs). This RFI is a critical step in supporting the deployment of domestic HALEU capabilities and regaining U.S. leadership in nuclear energy and the supply chain.

**Advanced Reactor Deployment is a National Priority**

The need to rapidly develop and deploy carbon-free energy sources has never been greater. Nuclear energy provides more than 50% of the carbon-free energy in the U.S. Nuclear power, through the operating LWR fleet and the deployment of advanced reactors, is poised to be an increasing contributor to carbon-free energy in the U.S. and internationally. Congress recognized the urgency to deploy advanced reactors and the HALEU fuel supply chain by establishing the ARDP and the Energy Act of 2020’s Advanced Nuclear Fuel Availability Program. Through these federally supported efforts and numerous privately funded efforts, the U.S. industry is working to reclaim its historical role as the leading provider of nuclear reactors and fuel. Doing so will support the rapid expansion of carbon-free nuclear energy and better position the U.S. to advance nuclear safety and non-proliferation policies around the world and support U.S. national security interests, while ensuring a robust domestic commercial industry for decades to come.

\(^1\) The Nuclear Energy Institute (NEI) is the organization responsible for establishing unified industry policy on matters affecting the nuclear energy industry, including the regulatory aspects of generic operational and technical issues. NEI’s members include entities licensed to operate commercial nuclear power plants in the United States, nuclear plant designers, major architect/engineering firms, fuel cycle facilities, nuclear materials licensees, and other organizations and entities involved in the nuclear energy industry.
DOE Must Act with Speed and Urgency to Support Domestic HALEU Production

Today, it is estimated that the companies selected for the demonstration pathway will require HALEU for their reactors beginning in 2024 to support fuel fabrication ahead of reactor startup. Currently, it is not possible to purchase HALEU between 10% and 20% from a commercial enricher in the United States, making these companies reliant on HALEU supply from Russia to meet their deployment timelines. The length of time it takes to establish the funding, obtain the necessary regulatory approvals, and then construct the necessary fuel cycle infrastructure creates special challenges for bringing advanced reactors to market. DOE is well situated to support the rapid deployment of domestic HALEU enrichment production and the associated transportation and deconversion infrastructure, but it must urgently act.

DOE should expeditiously establish the Advanced Nuclear Fuel Availability Program and prepare to immediately begin the funding opportunity process when Congress appropriates funding so that the deployment of HALEU infrastructure can begin without delay. DOE should incentivize the licensing, construction, and deployment of HALEU enrichment facilities, deconversion facilities, and associated infrastructure through a competitive procurement process. NEI’s recommendations for implementation are detailed in the attachment.

DOE funding requests must be at a level needed to address the challenges before us. DOE’s FY 2022 HALEU funding request and the funding levels authorized in the Energy Act of 2020 are insufficient to support the rapid development of a HALEU enrichment capability. NEI recommends a $200 million DOE annual budget request to help develop HALEU infrastructure through a fair and open competitive process. This level of funding must begin as soon as possible. Without this level of funding, the private sector would have no reason to believe that the DOE is serious about supporting the deployment of HALEU enrichment in a timely manner. In addition, the taxpayer and private investment that has been made in HALEU enrichment to date may be lost if the private sector does not view the DOE as being a serious potential partner.

We appreciate your consideration of these comments and stand ready to support DOE in ensuring the success of this program. Please contact Everett Redmond, elr@nei.org or 202-361-1876, or Nima Ashkeboussi, nxa@nei.org or 202-375-0490, if you have any questions.

Sincerely,

Douglas E. True

Attachment

C: Andrew Griffith, Office of Nuclear Energy, DOE
   Michael Reim, Office of Nuclear Energy, DOE
Nuclear Energy Institute’s Comments on the Department of Energy’s Request for Information on the HALEU Availability Program

Question 1:

Sec. 2001 of the Energy Act of 2020 directs the establishment and periodic updating of a HALEU Consortium to partner with DOE to support the availability of HALEU for civilian domestic demonstration and commercial use. Among other things, the Act envisions that the HALEU Consortium could: provide information to DOE for purposes of biennial surveys on the quantity of HALEU needed for commercial use for each of the subsequent five years; purchase HALEU made available by the Secretary for commercial use by members of the consortium; and carry out demonstration projects using HALEU provided by the Secretary under the program.

What types of organizations or other entities should be included in the HALEU Consortium? If your organization or entity might be interested in becoming a member of a HALEU Consortium, please describe the contribution your organization or entity could provide to the consortium. The description should include examples of the type of activity or activities for which your organization or entity is interested in partnering with the Department. Please also provide a point of contact for your organization or entity, including name, affiliation, email, and phone number.

Response:

NEI applauds the creation of a HALEU Consortium to advise DOE on aspects associated with the HALEU availability program. The Consortium should include commercial companies engaged in the HALEU fuel supply chain (e.g., uranium miners, converters, enrichers, deconverters, fabricators, transporters, transport package designers, and consultants), HALEU end users (e.g., advanced reactor designers, research reactor representatives, utilities, and medical isotope producers), and industry associations that can provide a holistic view on aspects of the nuclear industry and are invested in the success of the program. NEI is interested in becoming a member of the HALEU Consortium. NEI is well situated as the nuclear industry’s leading organization on policy, regulatory, and technical issues to provide DOE with sound advice on the collective interests of the HALEU supply chain and end user community. Most, if not all, of the industry participants interested in the HALEU market, as producers or end users, are NEI members. NEI’s access to and relationships with the industry can facilitate the timely sharing of information with DOE. The designated NEI point of contact is Dr. Everett Redmond, elr@nei.org, 202-361-1876.

Question 2:

Please identify any issues, including energy justice concerns, that may affect the implementation of the HALEU Availability Program under Sec. 2001 of the Energy Act of 2020, in an equitable manner that would further the development and deployment of advanced reactors and the establishment of a domestic commercial source of HALEU.
Response:

As fossil-fueled generating facilities are shut down, advanced reactors offer the opportunity to repurpose the sites and transmission infrastructure and to preserve jobs in the local communities. Micro-reactors could reliably provide electricity and heat to remote and underserved communities that currently rely on carbon-intensive fossil fuels. Establishing a domestic HALEU fuel cycle infrastructure – a prerequisite to the large-scale deployment of advanced reactors – will enable these economic benefits. Such benefits, in turn, will help advance energy justice, which DOE defines as “the goal of achieving equity in both the social and economic participation in the energy system, while also remediating social, economic, and health burdens on those disproportionately harmed by the energy system.”

NEI believes that nuclear energy’s clean-air generation, reliability, and economic benefits can help facilitate a socially and environmentally just transition to a decarbonized electric grid. In fact, the Biden Administration has identified carbon-free nuclear power as an essential part of achieving a net-zero CO2 economy by 2050. Secretary Granholm has described carbon-free nuclear power as “an absolutely critical part of our decarbonization equation.” As Acting Assistant Secretary Dr. Kathryn Huff further noted last year: “Nuclear can play a role in the transition to a clean energy economy by fundamentally enabling our nation’s targets for clean, carbon-free electricity as well as non-electric energy markets. We have the potential to decarbonize many industrial sectors in the United States and abroad.”

In support of a just transition, the nuclear industry has reiterated and augmented its commitment to furthering the objectives of fair treatment and meaningful involvement of all communities with regard to industry operations and activities. This commitment centers on four key principles: (1) actively engaging with disadvantaged communities to enhance mutual trust and understanding; (2) integrating environmental justice (EJ) considerations into business and operational practices; (3) supporting efforts that promote the equitable distribution of benefits from facility operations and activities; and (4) supporting related public policies. As the HALEU supply chain will sustain operations for many decades to come, it is important to have a strong foundation of community engagement and support. Utilization of existing fuel cycle infrastructure or locations, as appropriate, will further relationships with surrounding areas established over decades of engagement.

The regulatory and oversight framework that is in place today ensures that past harms, notably related to uranium mining, will not be repeated. Under the framework, any site that will provide HALEU services (e.g., enrichment, deconversion, fabrication) will have undergone extensive review and approval from the Nuclear Regulatory Commission (NRC) on the adequacy of the licensee’s technical and financial qualifications, site criteria, design safety, environmental impacts, operational programs, and site safety.

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1 See NEI, “Giving Coal Communities a Second Carbon-Free Life,” (Jan. 2022).
3 See, e.g., Written Testimony of Maria Korsnick, President and CEO, Nuclear Energy Institute, submitted to the Committee on Environment and Public Works, United States Senate (Feb. 9, 2022); Good Energy Collective, “Can Nuclear Energy Jobs Power a Just Transition?” (Jan. 19, 2022).
4 World Nuclear News, “USA needs nuclear to achieve net zero, says Granholm,” (June 17, 2021).
5 DOE, “Q&A: Acting Assistant Secretary Dr. Kathryn Huff Shares Her Vision for the Future of Nuclear Energy.” (June 24, 2021).
6 See NEI, Environmental Justice Principles.
Nuclear Energy Institute’s Comments on the Department of Energy’s Request for Information on the HALEU Availability Program

All stakeholders, including members of the public, are given notice as to how they may participate in the regulatory process.

The NRC conducts its licensing reviews in accordance with the Atomic Energy Act, NRC regulations, and the National Environmental Policy Act (NEPA). Additionally, the NRC has been addressing environmental justice (EJ) issues for over 25 years, and in 2004 issued its “Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions.” (69 Fed. Reg. 52,040; Aug. 24, 2004). The Policy Statement sets forth the Commission’s views and policy to address President Clinton’s 1994 Executive Order 12898, “Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,” and provides guidelines on when and how EJ will be considered in NRC licensing and regulatory actions. The NRC has also periodically examined and improved its EJ programs and guidance. In fact, the NRC is currently conducting a systematic review of how the agency’s programs, policies, and activities address environmental justice, and is engaging with internal and external stakeholders and interested persons representing a broad range of perspectives. 7 As a result, the NRC consistently has taken, and continues to take, a hard look at EJ issues as part of its reviews conducted under NEPA. The NRC has long engaged with local communities, including underserved communities, to provide relevant information about NRC-licensed and regulated activities and to obtain input from those communities in making key regulatory decisions. Furthermore, the NRC, under its Tribal Policy Statement (82 Fed. Reg. 2402; Jan. 9, 2017) and Tribal Protocol Manual (NUREG-2173), interacts with federally recognized Tribes to ensure any licensing decisions that have substantial direct effects on one or more Indian Tribes are made with Tribal consultation.

Question 3:

What are the most significant barriers to the establishment of a reliable market-driven, commercial supply of HALEU for advanced reactor research, demonstration, and commercial deployment? Please describe these barriers in detail, identify potential actions to address these barriers, and include the timeframes in which the issues should be addressed.

Response:

Many advanced reactors, including the majority of the Advanced Reactor Demonstration Program (ARDP) awardees, will require HALEU with enrichments above 10%, and fuel forms very different from those manufactured for the current light water reactors (LWRs). The main challenge with HALEU supply is that establishing a commercial-scale production capability requires tremendous upfront capital investment for new capacity designed and licensed to produce higher assay fuels: more than $500 million for enrichment and deconversion capacity. The required HALEU production capacity will not materialize commercially without a sustained customer base and the advanced reactors that need HALEU cannot be deployed without an economically priced supply of fuel. In addition, advanced reactor developers are not able to independently finance the required cost of building this infrastructure. In fact, all global commercial enrichment in operation today was deployed with some level of government funding and/or financing.

Nuclear Energy Institute’s Comments on the Department of Energy’s Request for Information on the HALEU Availability Program

Global competition is intensifying to design and build advanced reactors. Establishing a domestic HALEU fuel production capability in the near future is critical to U.S. leadership in this emerging advanced reactor industry and to advancing vital strategic interests of the U.S. Currently, it is not possible to purchase HALEU between 10% and 20% from a commercial enricher in the United States. The length of time it takes to secure financing, obtain the necessary regulatory approvals, and then construct the necessary fuel cycle infrastructure creates special challenges for bringing advanced reactors to market. NEI estimates that, working aggressively, it will take a minimum of four years from the time funding is secured before commercial scale enrichment and deconversion capacity could be operational at a new or expanded facility. Therefore, it is essential that HALEU-related activities proceed with urgency. The following actions should be taken immediately:

- DOE should expeditiously establish the Advanced Nuclear Fuel Availability Program as authorized in the Energy Act of 2020 and immediately begin an expedited funding opportunity or request for proposal process, while also expediting any required environmental reviews in parallel, to avoid delaying the deployment of HALEU infrastructure. Congress should fund DOE at a level of $200 million a year to execute this program. Initiating this funding level immediately will help pre-fund the program before the industry work begins, similar to how the ARDP was pre-funded in FY 2020 appropriations. Pre-funding will build confidence with the industry and enhance their ability to raise capital to support the deployment of HALEU fuel cycle infrastructure.

- DOE should incentivize the licensing, construction, and deployment of multiple commercial HALEU enrichment facilities in the U.S. through a competitive procurement process, with the initial facilities to be operational by 2027 and subsequent ones soon thereafter. Initial facilities could be operational in 2026 if contracts from DOE are in place in 2022. Each enrichment facility should be able to produce a minimum of 10 metric-tons of HALEU per year at competitive prices with the ability to scale up to meet future demand requirements. In addition to enrichment capacity, DOE should, through a competitive procurement process, incentivize the licensing, construction, and deployment of deconversion capacity equivalent to or greater than the enrichment capacity. The deconversion capacity must be able to produce both uranium metal and uranium oxide at competitive prices and must be operational when the enrichment facilities are operational. Additional detail is provided in the response to question 10.

Because of the time it will take to deploy commercial scale enrichment in the U.S. (a minimum of four years working aggressively after funding is secured), acquiring HALEU from international suppliers is essential in the near term to support the larger goal of timely deploying advanced reactors in the U.S. Some of the advanced reactor projects under way will be delayed without access to the international market. Deploying these reactors before 2030 is critical to achieving U.S. climate goals and positioning the U.S. to be a strong exporter of advanced reactor technology through the 2030s and 2040s when global decarbonization accelerates. In support of these national goals, the DOE and other government agencies should not impede the industry’s acquisition of HALEU from international suppliers under existing trade agreements. In addition, DOE should consider assisting with transportation and storage of HALEU by leveraging the existing U.S. supply chain capabilities. This could include already qualified transportation entities, certified packages, and licensed facilities with available storage capacity.
Question 4:

If the Department were to address the objectives of Sec. 2001 of the Energy Act of 2020 related to the creation of a fuel bank to supply HALEU for civilian domestic research, development, demonstration, and commercial use:

- What is the quantity (in metric tons/assay) of HALEU necessary for domestic commercial use for each of the next five years (2022 – 2026)?
- If a “stockpile” of HALEU were established to build confidence in the supply of HALEU supporting early orders for the deployment of advanced reactors in the commercial market, how large (in metric tons/assay) a stockpile would be needed?
- What siting and energy justice issues should the Department take into account as it considers the development of a program and how might the Department address those issues?

Response:

NEI surveyed our members in 2021 to identify the HALEU needs of the industry out to 2035. These data were provided, via letter, to the Secretary of Energy in December 2021 and are publicly available at: https://www.nei.org/resources/letters-filings-comments/2021-doe-updated-need-for-high-assay-low-enriched. Based on the projections of advanced reactor developers and fuel designers, it is estimated that the cumulative HALEU need by 2026 will be 125 MTU and 700 MTU by 2030. These estimates include deployments from U.S. developers in both the U.S. and in Canada.

As DOE continues to survey the industry for their HALEU requirements per the requirements in the Energy Act of 2020, NEI recommends that DOE request data for a time period longer than five years. The energy landscape is expected to change dramatically over the next decade and obtaining data only for the next five years may not fully indicate important trends. In addition, NEI recommends that the data collected address deployments by U.S. companies both in the U.S. and internationally. The HALEU enrichment and deconversion capacity that will be built in the U.S. should support both domestic and international markets.

NEI does not have a specific recommendation regarding the size of a potential “stockpile” of HALEU. However, it should be recognized that a large government-held inventory could have adverse market impacts in the future and efforts should be made to mitigate this risk. As mentioned in the previous response, NEI recommends that DOE incentivize the licensing, construction, and deployment of multiple commercial HALEU enrichment facilities in the U.S., through a competitive procurement process, with each facility able to produce a minimum of 10 metric-tons of HALEU per year at competitive prices. In addition to enrichment capacity, DOE should, through a competitive procurement process, incentivize the licensing, construction, and deployment of deconversion capacity equivalent to or greater than the enrichment capacity. The deconversion capacity must be able to produce both uranium metal and uranium oxide at competitive prices and must be operational when the enrichment facilities are operational. In addition, in the response to question 10, NEI recommends that DOE guarantees long-term offtake.

Please see the response to question 2 regarding Energy Justice issues.
Question 5:

Please identify any additional specific actions that would provide confidence in the short-term supply of HALEU and thereby to ensure the development of a commercial market for advanced reactor orders.

- What actions might be most useful for the U.S. Government to carry out?
- What actions might be most appropriate for the private sector to carry out?

Response:

It is vitally important that advanced reactor developers and their customers (current and potential) have confidence that HALEU enrichment and deconversion capacity will become available as quickly as possible in the U.S., at competitive prices, and be available for the life of the reactors. Without confidence in the security of the fuel supply chain, potential customers may be reluctant to make the financial investment in a multi-decade nuclear power generating asset. Through the federally supported ARDP projects and numerous privately funded efforts, the U.S. industry is working to reclaim its historical role as the leading provider of nuclear reactors and fuel. However, the long-term success of the projects depends on a guaranteed supply of HALEU.

The most important steps that the U.S. Government can take to bolster market confidence are related to program execution. The DOE must act with urgency and expeditiously establish the Advanced Nuclear Fuel Availability Program as authorized in the Energy Act of 2020 and immediately begin the funding opportunity or request for proposal process. Congress must also immediately provide adequate funding, $200 million a year, for DOE to execute the Advanced Nuclear Fuel Availability Program which it authorized in the Energy Act of 2020.

HALEU is currently available from an international supplier. However, this does not provide the long-term confidence that advanced reactor projects demand. Because of the time it will take to deploy commercial scale enrichment in the U.S., acquiring HALEU from international suppliers will be required in the near term to support the larger goal of deploying advanced reactors in the U.S. in a timely manner. Some of the advanced reactor projects under way will be delayed without access to the international market. To ensure these projects have access to this international supply, the DOE and other government agencies should not impede the acquisition of HALEU by industry from international suppliers within the framework of existing trade agreements. In addition, DOE should consider assisting with transportation and storage of HALEU by leveraging the existing U.S. supply chain capabilities. This could include already qualified transportation entities, certified packages, and licensed facilities with available storage capacity.

Question 6:

What level of market demand for HALEU over what timeframe is needed to stimulate investment in the infrastructure required to support a HALEU supply chain?
Response:

The ARDP projects and other privately funded demonstrations in the U.S. and Canada already have a cumulative average market demand of more than 10 MTU/yr. NEI expects the HALEU market demand will continue to grow and could be substantial by 2030 as the number of advanced reactor deployment projects increases. To support the development of HALEU enrichment and deconversion capacity in the U.S., NEI recommends that DOE incentivize the licensing, construction, and deployment of multiple commercial HALEU enrichment facilities in the U.S., through a competitive procurement process, with each facility able to produce a minimum of 10 metric-tons of HALEU per year at competitive prices, with the ability to scale up to meet future market demand. In addition to enrichment capacity, DOE should, through a competitive procurement process, incentivize the licensing, construction, and deployment of deconversion capacity equivalent to or greater than the enrichment capacity. The deconversion capacity must be able to produce both uranium metal and uranium oxide at competitive prices and must be operational when the enrichment facilities are operational. DOE should accomplish this through a combination of cost-sharing private-public partnerships to deploy HALEU production facilities and directly contracting for a bank of HALEU through multi-year contracts to guarantee demand for the production from those facilities. The aggregate of DOE’s HALEU contracts and the growing commercial market HALEU demand (beginning with the Advance Reactor Demonstration Projects and other privately funded efforts) will provide the necessary demand signals to support deployment of enrichment and deconversion capabilities in the U.S. Additional detail is provided in the response to question 10.

Question 7:

On what basis should HALEU be priced or valued? Please consider the options for the pricing of HALEU based on enrichment, weight, and/or separative work units and provide the pros and cons for each option or combination of options. Please discuss how pricing options would provide DOE with reasonable compensation and commercial entities with sufficient incentive to deploy domestic capacity to supply HALEU. What is your long-term estimated “price point” for the range of assays/enrichment (2030 and beyond)? Please consider and note the form of HALEU (e.g., metal, oxide, UF₆, etc.) in your response.

Response:

While NEI will not directly comment on price points, the cost of HALEU is an important factor in the cost of advanced reactor operations. In the U.S., fuel accounts for approximately 20% of total generation costs for currently operating light-water reactors. For advanced reactors, fuel will likely comprise a much larger portion of total generation costs. DOE’s program should support the deployment of production facilities that enable cost competitive HALEU enrichment and deconversion prices that can be as low as possible.

Enrichment services in today’s market are sold as SWU. HALEU pricing will likely follow a different model since 80% of the SWU required to produce 19.75% HALEU is expended to produce 4.95% LEU. It is likely, however, that existing facilities that produce LEU will be utilized to produce 4.95% (or 9.95%) enriched uranium which will be fed into new HALEU capacity to produce the desired enrichment up to 19.75%.
The price for the LEU feed to produce HALEU should be consistent with LEU market prices for the current operating fleet. There will be a price premium for HALEU enrichment as construction of new HALEU enrichment capacity is required for enrichments above 10% because of plant design (e.g., criticality), regulatory oversight, and operational and security considerations (enriched uranium above 10% is NRC Category II material and requires additional security and safeguards arrangements). The enrichment market has been in a prolonged period of low prices for the last several years. Today’s SWU prices do not support building additional enrichment capacity and even marginal increases to the current market price of approximately $60/SWU is not an incentive to build HALEU enrichment capacity. As a historical reference, Western enrichers have not deployed new enrichment capacity at prices under $120/SWU.

HALEU provided to the industry through the DOE Advanced Nuclear Fuel Availability Program should be appropriately priced. When needed, DOE should make the material available at a price that is consistent with Western HALEU market prices, including feed and deconversion cost considerations, at the time of contracting. DOE should not undercut the prices being offered by Western HALEU suppliers and should be an option of last resort in the case of insufficient supply available from an enricher.

Question 8:

Advanced reactors under development (including awardees under the Advanced Reactor Demonstration Program) would utilize HALEU in various chemical and physical fuel forms, including oxides, metals, and potentially salts. Additionally, centrifuge enrichment requires uranium in hexafluoride form. What additional fuel cycle infrastructure, or additions or modifications to existing infrastructure, would enable the deployment of commercial HALEU production and assure the availability of different forms of HALEU in sufficient quantities for use in advanced reactors?

Response:

The fuel cycle infrastructure needed to support the deployment of advanced reactors includes HALEU enrichment capacity (either centrifuges or other next generation technologies, such as laser enrichment), metal and oxide deconversion capabilities, commercially sized HALEU transportation packages for metal, oxide, and UF6, and fuel fabrication facilities.

Question 9:

How do you envision a HALEU supply chain as being responsive to the President’s Justice40 Initiative — a plan to deliver 40 percent of the overall benefits of climate investments to disadvantaged communities and inform equitable research, development, and deployment within DOE? Please provide specific actions and the type of benefits (e.g., employment, educational opportunities, etc.) that could be most useful to the targeted communities in response to the Justice40 Initiative.
Response:

Nuclear energy is overwhelmingly a net positive benefit for the environment. Nuclear energy powers 20% of the U.S. electrical grid and provides over 50% of the nation’s clean, carbon-free emissions electricity. The United Nations Intergovernmental Panel on Climate Change (IPCC) has calculated nuclear emissions as similar to onshore wind and lower than rooftop solar. The IPCC data includes the emissions associated with the nuclear fuel supply chain (uranium mining, conversion, enrichment, and fabrication). Rightfully, the Biden Administration has identified the need to maintain existing nuclear plants and deploy new nuclear reactors to meet climate goals. DOE support for developing a reliable, domestic, HALEU fuel supply chain is a critical component of fueling the reactors of the future and fits within the Administration’s Justice40 Initiative.

Historically, most fuel cycle facilities have been sited in rural, economically disadvantaged areas of the country. The sole conversion facility in the U.S. is in Massac County, Illinois, which has been identified as an underserved community. The only operating enrichment facility in the U.S. is in a rural community, with a large minority population, and is one of the larger private employers in the county. Additionally, the HALEU Pilot Project is sited in a rural, economically disadvantaged area. Funding to the likely applicants under the HALEU Availability Program would exceed the Justice40 goal of delivering 40% of benefits to disadvantaged communities, as a majority of the investment made would stay in the local community. The expansion of existing sites or the development of new HALEU infrastructure will result in significant training and employment opportunities in those communities with industries that enable a transition to clean energy.

Question 10:

What are some approaches or contracting vehicles that could be used by the Department to help enable the necessary commercial deployment of a domestic HALEU supply chain, including but not limited to mining, conversion, enrichment, deconversion, transportation, and fuel fabrication? For each, please discuss potential federal versus private sector actions; in addition, discuss leveraging robust partnerships for co-development of sub-elements of the supply chain.

Possible approaches that might be considered include:

- Production contracts (of what volume and length);
- Take-or-pay contracts (U.S. Government agrees to take specified volume of goods and/or services for a specified time period);
- Partnerships and/or cost-sharing of infrastructure development, including with allies and partners; and
- Payment-for-production milestones.

Response:

It is vitally important that advanced reactor developers and their customers and potential customers have confidence that HALEU enrichment and deconversion capacity will become available as quickly as possible in the U.S., at competitive prices, and be available for the life of the reactors. Without this
Nuclear Energy Institute’s Comments on the Department of Energy’s Request for Information on the HALEU Availability Program

confidence, potential customers may be reluctant to make the financial investment in a multi-decade nuclear power generating asset or face significant challenges acquiring capital.

To support the development of HALEU enrichment and deconversion capacity in the U.S., NEI recommends that DOE incentivize the licensing, construction, and deployment of multiple commercial HALEU enrichment facilities in the U.S., through a competitive procurement process, with each facility able to produce a minimum of 10 metric-tons of HALEU per year at competitive prices with the ability to scale up production to meet future market demand. In addition to enrichment capacity, DOE should, through a competitive procurement process, incentivize the licensing, construction, and deployment of deconversion capacity equivalent to or greater than the enrichment capacity. The deconversion capacity must be able to produce both uranium metal and uranium oxide at competitive prices and must be operational when the enrichment facilities are operational. DOE should accomplish this through a combination of cost-sharing private-public partnerships and directly contracting for a bank of HALEU through multi-year contracts. As DOE executes this program it should endeavor to create a program that is easy to implement and execute, while delivering, as efficiently as possible, commercial capacity that can be easily expanded to meet a growing market demand. This will help ensure success. In addition, DOE should ensure that facilities supported by the program will be allowed to sell HALEU to both the domestic and international markets.

Cost-sharing public private partnerships will reduce the level of private investment required to successfully deploy enrichment and deconversion facilities and should enable cost-competitive SWU and deconversion prices that can be as low as possible for the end customer. This is vital as the cost of HALEU is an important factor in the cost of advanced reactor operations. The cost-share structure should be consistent with Section 988 of the Energy Policy Act of 2005. A milestone-based approach should be used to execute the cost-sharing program. This approach should help optimize the contracting process and aggressive milestones, agreed to by all parties, will incentivize the rapid deployment of the facilities.

In addition to cost-sharing the deployment of facilities, NEI recommends that DOE guarantees long-term offtake of 10 MTU/yr from the enrichment and deconversion facilities until industry’s annual demands exceed the initially built enrichment capacity. The HALEU purchased by the government would serve as a “bank” of HALEU to be sold to the industry when HALEU production capacity shortfalls exist. This offtake should initially be UF₆ at 19.75%, as it is the most fungible form and could be downblended to the desired enrichment. Deconversion would then occur prior to delivery to industry.

To minimize the government’s role as a HALEU provider for the industry, DOE should reduce its offtake from its contracts if the industry purchases directly from the enricher and deconverter. If industry demand exceeds enrichment capacity in a particular year, DOE could sell some of the HALEU it acquired in previous years to the industry. When selling material to the industry, DOE should price it consistent with Western HALEU market prices, including feed and deconversion cost considerations, at the time of contracting. DOE should not undercut the prices being offered by Western HALEU suppliers and should be an option of last resort in the case of insufficient supply available from an enricher.

This “bank concept” differs from the concept of a “strategic reserve” because in the latter case the HALEU would be stockpiled until some event occurs (e.g., supply disruption) requiring the release of the
material to stabilize the market. In the “bank concept,” DOE would provide the HALEU it acquires as soon as the market requests it due to a production deficit. The duration of DOE’s guaranteed offtake and “bank” program should be driven by the market conditions. DOE should not terminate the program unless the industry has confidence that HALEU will be reliably available for years to come. At the end of the program DOE could either: 1) liquidate its stocks of HALEU to the industry, if this does not impact the front-end of the fuel cycle commercial market, 2) preserve the HALEU for ultimate use by DOE for its own purposes (e.g., research reactor use, medical isotope production), or 3) convert it to a strategic reserve.

DOE’s market pull, added with the market signal from early movers, like the two DOE ARDP awardees, should provide a sufficient demand signal to accelerate an investment decision for commercial enrichers.

**Question 11:**

What specific technological, regulatory, and/or legal gaps or challenges currently exist for transporting HALEU in various chemical forms (e.g., oxide, hexafluoride, metal) throughout the HALEU fuel supply chain? How do these challenges change depending upon the enrichment level? What actions could be taken, when, and by whom, to address the identified gaps or challenges?

**Response:**

There are no technological, regulatory, or legal gaps that exist for transporting HALEU. HALEU is currently transported globally with minimal issues. The challenge that exists is the lack of commercial sized HALEU packages and the lack of a market signal for package designers to design, certify, and build the containers. DOE could provide, through a cost-share or other mechanism, the incentive for industry to proceed with the certification of packages that can transport commercial sized quantities of HALEU in multiple forms.

**Question 12:**

Questions specific for transportation packaging companies:

i. What actions, either federal or non-federal, might help incentivize the development and delivery of a new or modified 30-inch cylinder? Please discuss incentive amounts and incentive areas (design, licensing, certification, overpack re-certification, etc.) as appropriate that would be most helpful to accelerate the delivery date.

ii. If your company were to receive an order for a 30-inch transportation package that is certified by NRC to contain enriched uranium hexafluoride up to 19.75 wt. percent Uranium-235, what do you expect would be the earliest delivery date possible? What do you anticipate would be its maximum loading?

**Response:**

DOE could provide, through a cost-share or other mechanism, the incentive for industry to design, certify, and manufacture commercially sized packages for HALEU in multiple forms.
Question 13:

Co-location of facilities for the front end of the fuel cycle (such as enrichment, and conversion/deconversion, and fabrication) may be a practicable solution to address some HALEU transportation issues. Is co-location considered otherwise beneficial? Are there other solutions that should be considered?

Response:

For today’s LWR reactor fleet, fuel fabricators receive UF₆ and deconvert it to uranium oxide and then fabricate it into pellets and fuel assemblies. Many of the advanced reactor designs will utilize different fuel forms: TRISO, metallic, and salts. As a result, many of the advanced reactor fuel fabricators do not plan to receive UF₆ but would prefer to receive uranium metal or oxide for fuel fabrication. Enrichers in the U.S. currently only produce enriched UF₆ and are not set up to deliver the other forms of enriched uranium that the advanced reactor market desires. To produce the desired products, uranium metal and oxide, will require the deployment of commercial deconversion capabilities in the U.S. concurrently with HALEU enrichment capacity. Multiple commercial HALEU enrichment facilities should be deployed in the U.S., through a competitive procurement process, with the initial facilities to be operational by 2027 and subsequent ones soon thereafter. Initial facilities could be operational in 2026 if contracts from DOE are in place in 2022. In addition to enrichment capacity, deconversion capacity equivalent to or greater than the enrichment capacity should be deployed through a competitive procurement process and must be operational when the enrichment facilities are operational.

Co-locating deconversion facilities with enrichment facilities would offer logistical and financial benefits. For example, Category-II security requirements could be optimized, common infrastructure could be maximized, and transportation between facilities would be minimized. If enrichment and deconversion facilities are co-located it is likely that they would be operated by separate companies. Therefore, NEI recommends that fuel cycle facilities be co-located (enrichment and deconversion or deconversion and fabrication) to enable the most efficient and cost-effective solution for the HALEU supply chain.

Question 14:

What factors affect the ability of U.S. uranium producers to provide uranium for advanced reactor fuel? Please indicate the importance of such factors and how they may be addressed.

Response:

U.S. uranium miners and converters are well positioned to benefit and support the deployment of advanced reactors. They can play a key role in supplying feedstock for HALEU enrichment. Due to market conditions, nearly all U.S. uranium production is on standby and the sole U.S. conversion facility suspended operations in 2017 and is in the process of a restart. Market prices and offtake certainty are among the key factors impacting U.S. uranium miners’ ability to supply uranium for advanced reactor needs. There are ample uranium resources in the U.S. to supply advanced reactors if market prices support mining operations. Similar to developing enrichment capacity, uranium miners prefer long-term contracts to justify the cost to restart or license new operations.
Question 15:

What are the technical barriers and/or regulatory requirements (e.g., safety, security, material control and accountability) to licensing front-end fuel cycle facilities (e.g., enrichment, deconversion, and/or fuel fabrication facilities) for the production and availability of HALEU?

- For existing facilities to upgrade to a HALEU capability?
- For new facilities?

Response:

Industry does not see any technical or regulatory barriers to licensing fuel cycle facilities to produce HALEU. Industry has successfully licensed and is currently operating fuel cycle facilities that produce high-enriched uranium. Additionally, the NRC granted a license to the Centrus HALEU Pilot Plant to operate with enrichments up to 20%. There is a regulatory gap in guidance for NRC Category II security for enrichments above 10%. However, NRC is reviewing these issues on a case-by-case basis to develop appropriate site-specific supplemental security measures. Industry engagement in this area has been positive and is not seen as a barrier to licensing.

Question 16:

What, if any, additional criticality and/or benchmark data is needed to meet U.S. Nuclear Regulatory Commission (NRC) safety and regulatory requirements that must be met in order to establish a supply chain capable of making HALEU available for the development and deployment of advanced reactors? Please consider and address both front-end fuel cycle facilities and transportation packages (including for metal, gas, and pertinent chemical forms).

Response:

The industry has determined that additional criticality benchmark data are not essential for licensing activities associated with the various aspects of the front-end of the fuel cycle. However, additional data would be beneficial to reduce conservatism in designs. If funding for the Advanced Nuclear Fuel Availability program is significantly constrained, NEI suggests that the development and deployment of enrichment and deconversion capacity be the top priority followed by support for transportation infrastructure and lastly support for additional criticality benchmark data.

Question 17:

What, if any, additional challenges or considerations may be associated with a HALEU lifecycle (including disposition), beyond those of a traditional light water reactor fuel cycle, and how can they be can be identified early and addressed?
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Response:

HALEU with enrichments above 10% is an NRC Category II material and will require additional security measures. There is currently a regulatory gap in guidance for NRC Category II security. This is a significant but manageable difference between the HALEU life cycle and the traditional LWR fuel cycle. However, NRC is reviewing these Category-II related issues on a case-by-case basis to develop appropriate site-specific supplemental security measures. Industry engagement with the NRC in this area has been positive and is not seen as a barrier to licensing.

Higher enrichments will also create additional criticality consideration that must be managed at enrichment, deconversion, and fuel fabrication facilities as well as during transportation. For example, the traditional 30B cylinder used for transportation of UF₆ up to 5% enrichment is being modified to accommodate enrichment up to 20%. However, due to criticality control issues the quantity of UF₆ will have to be reduced at 10% enrichment and further reduced at 20% enrichment compared to the quantity that can be shipped at 5% enrichment.

Enriching uranium to 20% will require significantly more natural uranium feedstock compared to enriching uranium to 5%. As a result, the quantity of uranium tails produced per metric ton of enriched uranium will be significantly greater. This is a manageable issue.

Question 18:

What other legal, funding, and other issues should be addressed to best enable the development of a HALEU availability program and promote private sector deployment of domestic HALEU production capacity?

Response:

An overarching theme in the execution of the Advanced Nuclear Fuel Availability Program must be ease of implementation and execution. In addition, the DOE must act with urgency and expeditiously establish the Advanced Nuclear Fuel Availability Program as authorized in the Energy Act of 2020 and immediately begin the funding opportunity or request for proposal process. Congress must also provide adequate funding, $200 million a year, for DOE to execute the Advanced Nuclear Fuel Availability Program which it authorized in the Energy Act of 2020.

Question 19:

Please describe the financial challenges associated with developing a sustainable commercial fuel supply chain for HALEU. Specifically, what are the challenges related to the acquisition of funds for investment in HALEU production infrastructure? How might these challenges be mitigated?

Response:

The financial challenge with developing the commercial fuel supply chain is making the decision to invest in a market where the customer demand is uncertain. Long-term contracts with well-established
entities (e.g., utilities) at prices that support operations and a return on capital will incentivize HALEU suppliers to deploy capacity. Unfortunately, HALEU users (e.g., advanced reactor developers and utilities) are not in a position at this time to enter into long-term multi-year contracts. DOE can mitigate this situation by providing a market signal through a combination of cost-sharing private-public partnerships and directly contracting for a bank of HALEU through multi-year contracts. Cost-sharing the deployment of enrichment and deconversion capacity should help reduce the cost of enrichment and deconversion services to the end customer. Suppliers with long-term contracts in-hand from established, credit worthy entities should not have a challenge acquiring funds to develop HALEU infrastructure. However, advanced reactor users can be expected to face significant challenges acquiring capital absent clear availability of HALEU fuel in the near and long-term. Contract certainty can enable suppliers to move forward to self-finance, obtain loans, or receive capital from financial markets to build production capacity. In the future, DOE support through the Loan Guarantee Program could be helpful to add additional capacity.

DOE support is essential to the development of a commercial HALEU supply chain. However, this support is contingent on Congressional funding. DOE funding requests and Congressional appropriations must be at a level needed to address the challenges before us. DOE’s FY 2022 HALEU funding request and the funding levels authorized in the Energy Act of 2020 are insufficient to support the rapid development of a HALEU enrichment capability. NEI recommends a $200 million DOE annual budget request to help develop HALEU infrastructure through a fair and open competitive process. This level of funding must begin as soon as possible. Without this level of funding, the private sector would have no reason to believe that the DOE is serious about supporting the deployment of HALEU enrichment in a timely manner. In addition, the taxpayer and private investment that has been made in HALEU enrichment to date may be lost if the private sector does not view the DOE as being a serious potential partner. Initiating this funding level immediately will help pre-fund the program before the industry work begins, similar to how the Advanced Reactor Demonstration Program (ARDP) was pre-funded in FY 2020 appropriations. Congress should also consider pre-funding the entire Advanced Nuclear Fuel Availability Program as was done with ARDP program in the Infrastructure Investment and Jobs Act. Pre-funding will build confidence with the industry and enhance their ability to raise capital to support the deployment of HALEU fuel cycle infrastructure.

**Question 20:**

What are the human resource-related considerations related to the buildout of commercial HALEU production?

- Are there specific recruitment and/or training challenges that must be overcome?
- What types of skillsets are needed to develop and deploy the domestic commercial production of HALEU? Would this increase the number of union jobs?
- Please describe the nature of any anticipated shortage in subject matter expertise and its potential impact.
Response:

NEI is not aware of any human resource-related challenges for deploying HALEU enrichment and deconversion capacity. The HALEU Availability Program may increase union jobs during construction and operation.

Question 21:

Are there additional considerations or recommendations, including the timing of various actions, that should be considered with respect to key challenges to HALEU availability for civilian domestic research, development, demonstration, and commercial use in the United States?

Response:

Processing of DOE Material

The processing of EBR-II fuel should continue and be expedited to ensure that it is available when needed for the company that plans to use it. However, before processing additional DOE stocks, DOE should determine if that approach is the best utilization of limited Advanced Nuclear Fuel Availability Program funding given that the ultimate goal is to establish a domestic commercial enrichment capability as quickly as possible.

Downblended and reprocessed stocks from the DOE may be potentially useful for some projects. However, because they are inherently finite, they do not provide the long-term fuel supply assurance that utilities will require. Only HALEU enrichment capability can provide the essential supply assurance. Therefore, pursuing these short-term options should not come at the expense of an aggressive effort to deploy domestic HALEU enrichment, and DOE should take care that downblended or reprocessed stocks do not effectively displace or delay commercial HALEU enrichment capacity, to the detriment of the entire industry.

The finite quantities available from processing DOE spent fuel will not be sufficient to address the first core and reload needs of all of the advanced reactor projects currently underway and therefore will not obviate the need for some companies to purchase HALEU in the international market until the domestic market provides HALEU. In addition, processing this material may be more expensive than HALEU produced from enrichment facilities and will do little to encourage the establishment of a domestic enrichment market.

HALEU derived from previously irradiated fuel is expected to contain some impurities that may make it unsuitable for particular reactor designs or fuel fabrication facilities. If the DOE chooses to process this material, the isotopic specification for the resulting HALEU should be reviewed with the customers/developers to determine if the material will be acceptable for use in their fuel fabrication facilities and reactors. Depending on the impurities in the HALEU, a fuel fabrication facility may have to utilize alternate procedures for handling and disposal that would increase fabrication costs and there may be a performance penalty in the reactor.
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Material Standards

ASTM has a standard specification for UF₆ below 5%. A similar specification is not currently available for UF₆ up to 20% or for uranium metal or oxide up to 20%. While some companies have begun work in this area, additional effort is needed to develop standards that would be applicable to all entities in the HALEU fuel cycle. DOE should consider assisting with this effort.

Back-end of the Fuel Cycle

Many advanced reactors utilize fuel that is in different forms and different initial enrichments than the operating LWR fleet uses. Advanced reactors will utilize dry cask storage and deep geological disposal. However, advanced reactor (HALEU) fuels present a new challenge towards achieving an integrated waste management system. Therefore, DOE should fund research and development activities that promote standardization and risk reduction to manage advanced reactor HALEU spent fuel efficiently and securely towards the goal of an integrated waste management system. This effort should be funded separately from the Advanced Nuclear Fuel Availability Program.

Environmental Reviews

DOE must act expeditiously to implement the Advanced Nuclear Fuel Availability Program to ensure the timely development of a robust domestic HALEU fuel supply chain. To that end, Sec. 2001 of the Energy Act of 2020 directs DOE to “prioritiz[e] methods that would produce usable HA-LEU the quickest,” and “to ensure that the activities carried out under this section do not cause any delay in the progress of any HA-LEU project between private industry and the Department” underway at the time of Sec. 2001’s enactment. (Emphasis added.) Thus, it is imperative that DOE not delay the issuance of any funding opportunity announcement (FOA) or request for proposals (RFP) to support enrichment capacity deployment, or issuance of final funding awards, pending completion of any environmental review for the Advanced Nuclear Fuel Availability Program.

Sec. 2001 of the Energy Act of 2020 does not mandate the preparation of an environmental impact statement (EIS) – programmatic or project-specific – or otherwise address the manner in which DOE must meet its obligations under NEPA. Moreover, neither Council on Environmental Quality (CEQ) nor DOE regulations require DOE to prepare a programmatic NEPA document for all DOE-administered programs. Given the nature and requirements of the program described in Section 2001, there also is no practical need for DOE to prepare a programmatic EIS or Environmental Assessment (EA) to support implementation of the Advanced Nuclear Fuel Availability Program. Federal agencies typically perform programmatic NEPA reviews when the actions under a specific program(s) are routine actions that will be done repeatedly and therefore are likely to have similar or generic impacts that can be evaluated at a broad scale, or when it is more efficient to “tier” site- or project-specific analyses to a broad-scope programmatic review document⁸. As discussed below, given that such circumstances are not present in the case of the Advanced Nuclear Fuel Availability Program, no clear efficiencies would result from DOE’s preparation of a programmatic EIS.

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⁸ See CEQ, “Effective Use of Programmatic NEPA Reviews” at 10 (Dec. 18, 2014) (“Using programmatic NEPA reviews allows an agency to subsequently tier to this analysis, and analyze narrower, site- or proposal-specific issues [to] avoid[] repetitive broad level analyses in subsequent tiered NEPA reviews ....”).
Specifically, while Section 2001 allows DOE to consider options for acquiring or providing HALEU from a stockpile of uranium owned by the Department (e.g., high-enriched uranium (HEU) that is downblended to become HALEU or HALEU that is produced by DOE research, development, and demonstration activities), such stockpiles are unable to provide the “adequate and reliable supply” of HALEU required by Section 2001 and needed to support the near- and long-term deployment of advanced reactors in the U.S. Thus, such actions by DOE are likely to be both discrete and temporary. The DOE will need to use a competitive selection process to incentivize private entities to license, construct, and deploy the necessary enrichment, deconversion, and transportation infrastructure.

The foregoing commercial activities will require specific licensing actions or authorizations by the NRC, not the DOE. Therefore, the environmental impacts of those actions, including any cumulative impacts, will be appropriately evaluated by the NRC through its NEPA review process, as implemented in 10 CFR Part 51. Indeed, Section 2001(a)(1)(2)(A) explicitly recognizes the NRC’s role in licensing or authorizing key activities necessary to carry out the Advanced Nuclear Fuel Availability Program (e.g., licensing of enrichment and fuel fabrication facilities, certification of transportation packages). Notably, the NRC already has approved a license application for the Centrus pilot enrichment facility up to 20%.9 Another company with DOE funding, BWXT, is processing HALEU (and HEU) in several forms under NRC special nuclear material licenses, associated NRC EAs, and DOE categorical exclusions.10 The NRC also has engaged in preapplication interactions with four commercial vendors considering license applications or amendments to permit production of HALEU and has received one formal letter of intent.11 In addition, the NRC is reviewing an amendment request for changes to an existing UF₆ transportation package design certification under 10 CFR Part 71 to allow shipment of larger quantities of HALEU in the form of UF₆.12 As such, there is no need for or greater efficiency from DOE preparing a programmatic EIS for the Advanced Nuclear Fuel Availability Program, particularly in connection with the program’s FOA/RFP and funding award stages.

Finally, NEI recommends that DOE use all practicable means to expedite any environmental review that the Department might conduct under NEPA and DOE regulations. For instance, DOE should evaluate the potential applicability of categorical exclusions contained in the agency’s NEPA regulations to cover specific actions taken by DOE to implement the Advanced Nuclear Fuel Availability Program. Further, DOE should make optimal use of NEPA tools like adoption, incorporation by reference, and supplementation where the NRC and DOE already have prepared or will prepare relevant site-specific NEPA analyses (in contrast to tiering off of a programmatic EIS).13 Such measures will ensure that any

9 The NRC’s approval of the amendment is available at NRC ADAMS Accession No. ML21138A826.
12 See Letter from F. Hilbert, DAHER NUCLEAR TECHNOLOGIES GmbH to P. Saverot, NRC, “Subject: Proprietary application for the DN30-X package,” (June 29, 2021), NRC ADAMS Accession No. ML21381A001.
13 For example, the NRC has issued an EIS for the American Centrifuge Plant (ACP) (and DOE has adopted that EIS), an EA for the related Lead Cascade Facility (LCF), and an EA for the ACP license amendment that authorizes American Centrifuge Operating, LLC (ACO) to produce HALEU in the quantities and with the enrichment levels required by its HALEU demonstration contract with DOE. Any new enrichment, deconversion, or fuel fabrication facilities (or modifications to current facilities) necessary to support implementation of the Advanced Nuclear Fuel Availability Program will require NRC licensing and site-specific NEPA reviews. DOE has prepared an EA for processing spent Experimental Breeder Reactor-II (EBR-II) driver fuel to recover HEU and downblend it to just under 20% enrichment for use at the INL site.
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environmental review performed by DOE does not unduly delay implementation of the Advanced Nuclear Fuel Availability Program.