NEAC International Subcommittee Report

March 18, 2019

Prepared by

Regis Matzie – Chair
Lisa Marie Cheney – Co-Chair
David Blee
Jay Faison
John Hopkins
Sue Ion
Sarah Lennon
Allen Sessoms
Shannon Bragg-Sitton

(Revised Mar. 12, 2019)

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1. Executive Summary

The charter of the Nuclear Energy Advisory Committee (NEAC) International Subcommittee states that its primary objective is to provide independent expert advice and guidance related to opportunities for improving U.S. competitiveness in the global nuclear energy market and re-establishing the Nation's historic leadership in the field and to review related activities within the Office of Nuclear Energy (NE) and report its findings, recommendations, comments, and guidance to the NEAC and the Assistant Secretary for Nuclear Energy.

In the era after President Dwight Eisenhower's "Atoms for Peace" speech at the United Nations General Assembly on December 8, 1953, the U.S. nuclear industry was preeminent globally in commercial nuclear energy. The industry grew out of the naval nuclear power program with the launching of the USS Nautilus (SSN-571) in 1955 and the first demonstration pressurized water reactor (PWR) at Shippingport, PA, in 1957. Commercial nuclear power in the U.S. started gradually in the 1960s but accelerated dramatically in the 1970s and 1980s with approximately 100 light water reactors (LWRs) commencing commercial operations during this period. Today, there are 99 commercial reactors operating and 2 under construction in the United States, with many operating reactors threatened by premature closure due to current energy market structures. Further, the performance of recent new reactor build projects by U.S. suppliers has been less than acceptable. This is not the legacy that President Eisenhower envisioned when he gave his famous speech more than 65 years ago. Who would have thought that the U.S. nuclear industry would be viewed as "dying" by many in both the domestic and international communities, instead of continuing to be the driving supplier and innovator for the global industry?

The vast majority of commercial nuclear reactors operating globally are a result of U.S. technology. The technological expertise necessary for other vendors to develop was the result of many years of exporting reactors by U.S. vendors and/or technology transfer to countries like France, Japan, South Korea, and more recently China. These exports not only helped to strengthen U.S. industry and provide jobs domestically, but also provided a means of building policy influence over the utilization of civil nuclear energy from perspectives of safety, security, nonproliferation, and a strict regulatory approach. This influence is a byproduct of a 100-year relationship with the host country that comes from selling a civilian nuclear power plant, through the construction, operation, and decommissioning of the facility.

Today, our influence on global nuclear commerce has diminished. Russia and China have taken the lead as builders of the vast majority of new reactors. These reactor projects are often accompanied by extensive and early training in the supplier's country, comprehensive financing of the entire project, and, in the case of Russia, used fuel take-back. Other packaged benefits can include carbon-based fuel supply, arms supply, aviation supply, etc., which are not usually part of a U.S. nuclear power plant offering. These two supplier countries are not members of the Organization for Economic Cooperation and Development (OECD) and thus do not have to adhere to the OECD rules on financing and do not need to follow certain nuclear protocols that U.S. suppliers do, e.g., U.S. Atomic Energy Act 123 Agreements for

Peaceful Cooperation, which often result in long delays in engaging potential customers by U.S. suppliers.

With these facts in mind, this report recommends actions that respond to the charter given to the International Subcommittee by the DOE to improve U.S. international nuclear competitiveness and re-establish U.S. historical leadership. The Subcommittee believes that the United States must re-engage the international civil nuclear market from a position of strength; the Subcommittee encourages actions described in this report that will take advantage of new global opportunities that can be exploited based on U.S. strengths related to nuclear energy technology. At the same time, U.S. weaknesses must be addressed and threats countered by specific actions, some of which are part of these recommendations. In formulating our recommendations, the Subcommittee was guided by a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis presented during one of our meetings and documented in Appendix D. The recommendations made in this report often go beyond the purview of the Department of Energy, but they are within the capabilities of the U.S. Government and its agencies. The major recommendations are:

- **Take steps necessary to position U.S. nuclear energy industry to have an equal or greater competitive advantage compared to other international suppliers, particularly those that are State-Owned-Enterprises (e.g., China and Russia) and thereby have the ability to successfully compete for new global business. Suggested actions include:**
  - Use a "whole of government" approach to achieve improved financing options,
  - Streamline of U.S. export controls to allow faster engagement,
  - Appoint of a Special Assistant to the President and Envoy for Nuclear Energy Policy (SAP ENEP) to coordinate across government departments and agencies, and
  - Capitalize on the new authorities given to the U.S. International Development Finance Corporation (USIDFC) in the BUILD ACT signed into law on October 5, 2018.
- **Aggressively pursue domestic deployment of new advanced reactors, which can be the linchpin to regaining U.S. leadership in the international nuclear community through the innovation that our engineers and scientists have demonstrated.**
- **Expand the U.S. commercial trade presence in the international nuclear market through initiatives such as:**
  - Energy technology trade missions that prominently include U.S. advances in nuclear energy, and
  - Implementation of training and education programs for students and professionals from near and mid-term market countries.

- **Revitalize the U.S. nuclear infrastructure, which is critical in maintaining global competitiveness and our national leadership in reactor safety, nonproliferation, safeguards and security. Suggested specific actions include:**
    - Build the Versatile Advanced Test Reactor, just given the go ahead by DOE, to obtain a fast neutron irradiation capability that is needed for many of the innovative technology developments now being pursued in the U.S.,
    - Increase funding for training at U.S. colleges, universities and national laboratories for both U.S. nationals and nationals of near and mid-term nuclear power consumer countries, and
    - Increase funding for nuclear R&D and for initiatives that would help regain U.S. advanced manufacturing capability.
- **Pursue strategic international collaborations that could allow the U.S. to be successful in new nuclear proposal opportunities by providing a more comprehensive bid package that could compete with others that include elements provided by state backing.**
- **Develop and deploy enhanced communications messaging that shows a renewed U.S. commitment to nuclear energy,**

A discussion of the bases for these recommendations is provided later in this report along with a listing of the meetings and presentations provided to the International Subcommittee from which these recommendations have resulted.

2. Introduction

The Historical Situation

The past success of the U.S. nuclear enterprise has been clearly recognized by the international community. The United States has the largest operating fleet of civilian nuclear reactors with consistent excellent performance over the past two decades. The capacity factors have year-after-year hovered around 90% as a result of the diligent efforts by the reactor operators and the entire industry, e.g., INPO, EPRI, NEI, etc., to achieve ever-improving economic operation. While this impressive operating performance has been achieved, the safety record has also been outstanding, including industrial safety with an extremely low number of accidents resulting in lost work. This performance has been achieved with 99 operating reactors that have generated more than twice the electricity of the next highest country – France.

Other outstanding sectors of the U.S. nuclear enterprise are its safety authority, the Nuclear Regulatory Commission (NRC); the U.S. national laboratory complex with INL being the lead nuclear laboratory; and U.S. universities with science and engineering programs that focus on nuclear energy. These sectors are valued globally as evidenced by broad participation when possible by personnel from other countries. The NRC is regarded as the "gold standard" of regulatory bodies with its very stringent and well-documented processes. The U.S. laboratory complex has numerous collaborative programs with R&D facilities throughout the world. Our Universities are most sought after by foreign students wishing to obtain advanced degrees in nuclear science and engineering.

The Picture Today

Despite these successes, the U.S. nuclear industry has recently been in decline due in part to a weak domestic market and an inability to compete on a level playing field in the international market. The weak domestic market was stalled first by the Three Mile Island accident in 1979, then by a flat electricity demand for many years starting in the 1970s, followed by the Fukushima accident in 2011, and most recently by very inexpensive pipeline natural gas, resulting from hydraulic fracturing ("fracking"). In addition, U.S. domestic electricity markets have given preference to renewable energy sources through the use of capital subsidies, production tax credits, and policies that require taking their generated electricity first. These practices result in markets that do not properly value nuclear energy for its safe, stable, base-load capacity. As a result, some of the United States' nuclear capacity has been shut down prematurely and many other reactors are threatened with the same fate. Finally, only two reactors are under construction in the United States and these have been plagued by delays and cost overruns, further hampering the reputation of nuclear energy as a cost-effective reliable means of energy production in the United States. It is important to note that blame for these delays and overruns is shared between the U.S. nuclear energy industry for failure to have completed adequate construction detail and failure to apply proper project controls on these very complex projects; and the USG for failure to support stable and sustained funding and policy commitments over the previous decades, which allowed the expertise to complete such project on schedule and budget to atrophy during the long period of inactivity.

The international nuclear market was once dominated by the United States with the vast majority of overseas plants of U.S. origin or resulting from technology transfer from U.S. companies to foreign entities, which then built indigenous nuclear plants. The success stories of such technology transfer have been demonstrated in France, Japan, South Korea, and many other, smaller countries. More than 70% of all operating reactors worldwide today are based on U.S. technology. However, this metric has quickly changed over recent years. The United States is no longer the sole innovator in nuclear technology nor is it in a lead position to offer competitive bids to build, deploy and operate new reactors to the global market.

This shift is due in large part to the fact that other countries have put in place substantial efforts to develop advanced civilian nuclear technology and that vendors from other countries can offer more attractive state sponsored finance, build and operate bids than U.S. companies. U.S. based companies, in general, must bear the full costs of the project in their bid proposals. In addition, it is more difficult for U.S. companies to get export approval from domestic agencies. Today, state-owned companies in China and Russia are capturing the vast majority of new reactor opportunities. They can package other attractive non-nuclear features, such as carbon-based fuel supply, arms supply, aviation supply, etc., as part of their efforts to win nuclear reactor bids. Their export control approvals can be obtained in 1 to 3 months while U.S. approvals can take 12 to 18 months. Currently, U.S. companies cannot get full or sufficient financing from the U.S. Export-Import Bank ("Ex-Im Bank) because it does not have a full Board of Directors. Even when this obstacle is overcome, OECD rules limit U.S. financing options.

The demand for nuclear energy generation across the globe continues to grow. However, the United States' role as the dominant supplier and arbitrator of that market is has decreased substantially. If the United States wants a seat at the global nuclear energy table, and an ability to influence policy and provide nuclear safeguards, it must be a dominant player in the international market. As noted in the International Subcommittee's April 2017 report, the majority of all commercial reactors under construction today are of Chinese and Russian design. Russia and China are aggressively seeking the Middle East market, and China continues major development projects that will give it the world's largest nuclear fleet in the relatively near future. Russia is sealing nuclear development deals by offering used fuel take-back contracts as part of their design and construction build to customer nations. This not only puts the United States vendors at a disadvantage, but more important, it is a real national security disadvantage to the U.S. The United States is currently on the outside looking in, and our lack of investment and of strong government support for our nuclear energy industrial and research base continues a negative trend. A nuclear world without strong U.S. participation will be more dangerous and volatile, and will undercut vital U.S. national security, environmental and safety interests.

So, what can be done? This report, as has the past two NEAC International Subcommittee reports issued in 2015 and 2017, recommends actions that DOE and the U.S. Government can take to try to change the current situation in which U.S. companies and the U.S. nuclear enterprise is seriously disadvantaged in trying to regain our position as the premier nuclear country in the world.

DOE Charter to the NEAC International Subcommittee

DOE issued a Charter to the NEAC International Subcommittee on September 13, 2018. See Appendix B for a copy of the full Charter letter. In this Charter, DOE states:

"The purpose of the International Subcommittee is to provide expert advice and guidance to the Assistant Secretary of Nuclear Energy, through the Nuclear Energy Advisory Committee (NEAC), on international nuclear energy policy which aims to support U.S. competitiveness in the global nuclear energy market and reestablish the Nation's historic leadership in the field thereby ensuring the safe, secure and peaceful expanded use of nuclear energy in a manner that minimizes the risks of proliferation. As nuclear energy continues to expand internationally, U.S. leadership is being significantly challenged by countries such as Russia and China and their state-owned nuclear entities. State sponsorship, attractive financing options, human resource development and bundled services, such as fuel takeback, are helping these countries achieve a significant competitive edge over U.S. nuclear vendors. Therefore, it is critical to consider every possible option to revitalize and expand the U.S. nuclear industry presence and it global leadership."

In carrying out this Charter, the International Subcommittee met twice to obtain input from knowledgeable stakeholders and to discuss how to respond to DOE's request. These meetings were held in Washington, DC, at the DOE Headquarters, on October 18-19, 2018, and January 10-11, 2019. The agendas for these meetings, showing the participants and subjects presented, are included in Appendix A.

A potentially important analysis tool used by the International Subcommittee during this second meeting was the discussion of a U.S. Global Competitiveness Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis. In addition to the Subcommittee members present, several staff from DOE also participated, and staff from Verdigris Capital facilitated the analysis. The results of this SWOT analysis are shown in Appendix D. It is readily apparent from this effort that the U.S. nuclear enterprise has many strengths. At the same time, it has a number of weaknesses and challenges that must be overcome to be competitive in the international marketplace. The United States should capitalize on the opportunities shown in the SWOT analysis and this approach is the basis of many of the recommendations provided in this report.

3. Level the Playing Field

The Administration has expressed the willingness to increase the domestic use of nuclear energy and regain the prominent position that the U.S. previously had; now we must chart the way. "*We will begin to revive and expand our nuclear energy sector…which produces clean, renewable and emissions-free energy. A complete review of U.S. nuclear energy policy will help us find new ways to revitalize this crucial energy resource."* President Trump at U.S. Department of Energy, June 29, 2017

This section of the report will address how the U.S. Government (USG) can work to level the playing field against other international nuclear suppliers.

A. Support for the Existing U.S. Nuclear Fleet

It is essential for the United States to preserve the existing fleet and limit premature reactor shutdowns. The United States is perceived by the international community as a reluctant supporter of nuclear energy as evidenced by its inability to sustain its operating fleet of reactors, along with the lack of sufficient and sustained investment for the construction of new reactors to replace retiring plants. In addition, the USG has failed to provide a robust policy and financial investment in support of a new domestic nuclear energy infrastructure. Our antiquated infrastructure hampers our ability to delivery large volumes of clean non-carbon emitting energy in a fast and efficient manner, and thus weakens our ability to be a provider on a global scale. The lack of financial and policy support by the USG for large nuclear plants in the United States is noted by nations around the world. That lack of USG support is driving nations to turn to other providers for the technology, and those providers are all too eager to supply their technology and workforce, in order to achieve major influence in these new customer nations.

In order to bolster U.S. support for our existing fleet, the Subcommittee recommends the USG take steps to level the domestic energy field. Across all agencies and programs, well beyond DOE, a common practice is to build in resiliency and reliability, and that should include the U.S. energy programs.

As recommended in the April 2017 report from this subcommittee, the subcommittee members once again strongly urge the Congress and the Federal Energy Regulatory Commission to enact laws and establish regulations to put all power generation sources that supply clean, reliable electricity on a 24/7 basis on an equal footing with those intermittent

sources that currently receive preferential treatment. The re-designation of nuclear energy as a **Renewable Energy**, (or as a part of the Clean Energy Standard), would send a strong message to our domestic nuclear energy industrial base, as well as to global customers. This change in designation would allow our nuclear energy vendors to compete for added federal funds supplied in the annual U.S. appropriations. It would allow our U.S. companies to benefit from tax incentives and provide tax benefits and lower energy costs to U.S. consumers. Nuclear energy is a low carbon emission resource, and low carbon emission is one of the defining characteristics of renewable energy. The change in designation would also allow nuclear energy providers to compete and be awarded R&D dollars from the Advanced Research Products Agency-Energy (ARPA-E). Instead of terminating funding for ARPA-E, the USG could change the focus of the organization toward more robust funding for nuclear energy R&D and education.

B. Enhanced Coordination to Increase Global Nuclear Market Share

The United States should consider a four-fold effort to increase its global nuclear energy market share:

- Establish a coordinated and well-organized business development campaign that will provide an impetus to U.S. industry by providing strong and sustained government support and backing.

- Improve financing options to incentivize investment, both public and private.

- Offer Nuclear Energy Site Security as a bundled service with new reactor bids.

- Reform and modernize export controls and 810 authorizations and conclude outstanding civil nuclear trade agreements (123 Agreements).

Coordinated and Well-Organized Business Development Campaign

It is essential to our energy economics, and our national security, that the United States rebuilds and upholds our role as a leader in nuclear energy development and deployment around the globe. The future strategy for the successful reinvigoration of the U.S. nuclear energy market will require USG financial support coupled with a directed change in how the USG views civil nuclear energy. It should be a central component of our national security strategy. As recommended in a previous NEAC report from October of 2017, civil nuclear energy should be a foreign policy strategic imperative, with strong coordination across USG agencies. To enable this coordination, the International Subcommittee of the NEAC strongly recommends the President establish a Special Assistant and Envoy for Nuclear Energy Policy.

Special Assistant to the President and Envoy for Nuclear Energy Policy

Nuclear policy has a unique and critical requirement for federal coordination because of its potentially broad implications on U.S. international initiatives. U.S. nuclear trade is subject to unusually complex statutory and regulatory requirements, including bilateral cooperation agreements and an export-control regime that is administered by three departments and several agencies. The Special Assistant to the President

and Envoy for Nuclear Energy Policy (SAP ENEP) would have a crucial role in creating coherence in U.S. policy on nuclear energy issues, enhancing the competitive position of the U.S. civil nuclear industry and furthering U.S. nuclear safety, security and nonproliferation goals. This position, which would have advocacy authority, is essential to interagency coordination on nuclear issues between the Departments of Commerce, State, Energy, Treasury, the NSC, the U.S. Trade Representative and the Export-Import Bank.

The SAP ENEP would be instrumental in the coordination and integration of all USG nuclear energy and policy strategy with all of the agencies listed above. These agencies would be actively involved in domestic and international advocacy to promote the U.S. commercial nuclear energy interests with the confidence and full support of the USG and our financial investors. The core advocacy will be to promote U.S. investment, build and operation of nuclear energy infrastructure globally from cradle to grave—a guarantee of an 80 - 100+ year relationship with customer nations. The creation of this position would reestablish U.S. credibility as a leader dedicated to international business development promoting U.S. nuclear energy capability, safety and innovation.

Improve Financing Options to Incentivize and Revitalize Investment in Nuclear Energy

The Subcommittee members unanimously agreed that one of the keys to providing substantive support for U.S. industry participation in the global nuclear energy market must address new means of financing U.S. nuclear energy products. As noted in the final NEAC International Subcommittee Report Dated April 6, 2017, the most urgent need is a means for U.S. companies to obtain adequate financing for both domestic and international projects, allowing them to compete with state financed suppliers like China and Russia. Financing continues to be a major issue for international customers, especially for the developing nations that can't self-fund large infrastructure projects. Our peer competitors in the nuclear energy market mentioned above come to the negotiating table with state supported financing from the state treasury and Export Credit Agencies (ECAs). The business delegations from these countries are often led by the heads-of-state and the offer is well-coordinated across their government. This high-level government support and coordination allows for proactive and early sales pitches in new and emerging markets. Their coordinated long-term strategy has been clearly articulated internally, and now they are executing on their goals for expanding near and long-term engagement with future commercial supply and operations. All of this allows for competitor speed to market.

The U.S. key investment ECA, the EX-IM Bank has been hobbled with no fully approved Board of Directors since 2015. New Board members have been nominated, but the Senate has yet to approve the nominations. The Subcommittee recommends DOE, the U.S. nuclear industry, and the White House work with the Senate, expressing the urgency of **confirmation for Ex-Im Board of Director nominations**. A full Board of Directors must be appointed so an appropriate level of financing can be available to U.S. nuclear export companies. A competitive ECA is imperative to U.S. bidding success in the international market. As such, the Subcommittee recommends the SAP-ENEP convene

monthly meetings with the Ex-Im Bank, the U.S. Trade Agency, the Overseas Private Investment Corporation (OPIC), its successor entity, and the U.S. International Development Finance Corporation (USIDFC), to coordinate funding opportunities to ensure the availability of export credit financing and establish new financing vehicles for U.S. civil nuclear industry.

Innovative financing options that incentivize long-term investors are greatly needed. As noted above, the first step is to confirm all members of the Board of Directors of the Ex-Im Bank. Options like **government backed loan guarantees**, which reward private venture investment for the long-term by reducing the risk and assuring the return with a healthy profit once the reactors are deployed and operational. Terms of loan should be at least 15 years and preferably longer.

A second innovative approach would be the establishment of **a Nuclear Energy Reinvestment Program (NERP)** designed after the principle of the Troubled Asset Relief Program (TARP) which were used with success to bail out U.S. banks and the U.S. auto industry. The USG can buy preferred stocks and bonds from the nuclear energy construction companies to finance the construction, fuel load, and early operation of the nuclear reactors. The government could then be paid back over period of 10 to 15 years through 9% dividends annually. This is like the Japanese and European banks' practice of infusing cash into their companies, and it would greatly reduce the competitive disadvantage for U.S. nuclear energy companies, allowing them to compete with their foreign rivals in this market. Once the nuclear energy industrial base is competitive again in the global market, the need for the NERP would diminish, and the USG will have recouped the investment plus interest.

Focus on U.S. Nuclear Energy Security as a Bundled Service

On June 26, 2018, 77 leaders from our national security community sent a letter to the Secretary of Energy commending him for his support and recognition of the value of our civilian nuclear energy industry. As noted in that letter, our nation's nuclear power plants are among the most robust elements of the U.S. energy infrastructure. Further noting that the Department of Defense depends on the nation's electrical grid to power 99 percent of its installations, and disruptions to this supply can greatly affect the nation's ability to defend itself.

The Subcommittee recommends as part of our pursuit of the international civilian nuclear energy market, the U.S. also offer our security services as part of the design, build and operate package. Many already believe if there were to be a man-made threat to nuclear reactors in any of our friend and ally nations, the U.S. military would be called to help protect those assets. As part of a U.S. offering, the physical and cyber security protection of the reactors and supporting infrastructure could be part of the deal. This would reinforce security, help to strengthen the application of U.S. safety and nonproliferation standards and assure a U.S. relationship with those customer nations from the cradle to the grave of the reactor and reactor infrastructure life cycle.

Reform and Modernize Export Controls and 810 Authorizations and 123 Agreements

The United States must improve the efficiency, predictability, transparency and speed of the Part 810 Authorization licensing process. U.S. industry must fight a slow regulation and export control process, and a 123 Agreement process, which may have been undermined by some past agreements. If our near-term state-owned competitors can process a request in 5 weeks to 3 months, we must substantially reduce our 12-18-month process. The Subcommittee recommends the new SAP ENEP work with the Secretary of Energy and take a proactive role by aiding recipient countries in understanding the process and required information to turn the request around in an expeditious timeframe.

The SAP ENEP should work with the relevant federal agencies to establish the parameters for licensing for export of SMR and small Advanced Reactors technologies and fuels. The United States should be proactive and assure the steps and necessary requirements are known and in place now for companies to begin requesting licenses for SMR reactors, and infrastructure components. This should include the export of Accident Tolerant Fuels (ATFs). Further, the USG should expand the "fast-track general authorization" adopted by the Congress in 2015 to include SMR technologies and ATFs.

The United States must recognize there is a tainted view of the 123 Agreements. It must also recognize that our competitor state-owned nuclear energy suppliers require no such agreements. The Subcommittee by no means recommends forgoing 123 Agreements, however, the Subcommittee recommends that the USG consider the above recommendation that Nuclear Energy Security be a bundled service and become part of the 123 Agreement. The State Department should conclude and/or renew agreements for peaceful nuclear cooperation under section 123 of the Atomic Energy Act quickly, especially with new entrants into the nuclear energy market.

The SAP ENEP should take the whole of government approach to streamline the nuclear authorization process while maintaining the intent of the current regulations. It is also imperative that the SAP-ENEP hold quarterly meetings with representatives of the civil nuclear energy industrial base. The only way to clearly understand and address the issues facing our civil nuclear energy sector, is to allow for an open engagement and exchange of ideas to help expedite their access and success in regaining market share in the global nuclear energy market.

4. Domestic Deployment of New Advanced Reactors (LWR SMRs, Micro Reactors, and Advanced non-LWR reactors) is the Linchpin to Regain USG Leadership

The Subcommittee offers three recommendations to help further the domestic development and deployment of new advanced reactors.

A. Expand USG Support and Funding for New Advanced Reactors

Success in deploying new advanced nuclear technologies in the United States is the linchpin to regaining U.S. leadership around the world. The U.S. must capitalize on our position as a technology leader in new and advanced reactor technologies and designs. The U.S. commercial industry is developing cutting-edge advanced reactor designs that have unprecedented versatility, can be paired with renewable generating sources, are much less

expensive than the larger full-scale reactors, burn waste as an energy source, and are walk-away safe. However, would-be nuclear plant customers are often reluctant to consider new and unproven technologies for purchase without these technologies having been first demonstrated to confirm technical feasibility, confirm that they can be licensed by the NRC, and that they are economically viable. While suitable safety and operational performance must be demonstrated at satisfactory levels, potential customers, when deciding whether to purchase a new technology, are motivated by economic considerations in comparison to those of other competing technologies. Many customers are unwilling to accept higher costs associated with first-of-a-kind projects and instead are often willing, if time and other factors permit, to wait until the technology has been acceptably demonstrated, and pricing is more in line with accepted norms. Until these new technologies have been successfully demonstrated, their sales potential is greatly hampered.

Therefore, demonstrating the commercial viability of these technologies in the United States will prompt those domestic and foreign nuclear generation developers interested in advanced nuclear deployment to consider U.S. developed technologies. First mover risk will be eliminated or substantially reduced by such demonstrations.

Bringing an advanced nuclear technology from concept to deployment is generally a lengthy and very expensive undertaking. Experience from recent new nuclear technology programs indicates that the cost to bring a new commercial reactor technology from concept to "ready for construction" can cost well more than a billion dollars regardless of the size of the technology, with the possible exception being micro-reactors. . The current experience associated with bringing a new nuclear technology to fruition is essentially limited to new advanced light water designs for which there exists well over 60 years of operational and licensing experience. It's uncertain what the costs might be to fully develop a new advanced non-light water reactor technology for which limited operational and current regulatory licensing experience exists. The general assumption is that such costs will be comparable, if not higher, for non-light water designs.

The time needed to develop and test the design and its first-of-a-kind components, and to prepare the information associated with nuclear regulatory review and approval, the regulatory review and approval period, and the time needed for design finalization can add up to an overall development period of well over 10 and possibly 20 years.

These high costs and a long development time frame make attracting significant private investment into these programs very difficult. Technologies that show promise at the conceptual stage of development, are still unlikely to survive through the "valley of death" of development as companies struggle to find the financial means to advance their technology through mid-level (4-7) technology readiness levels (TRL) of development to a point where customers and technology investors believe that the technology is a proper investment with returns expected in a reasonable timeframe.

The U.S. Department of Energy (DOE) has a long history of initiating assistance award programs that promote U.S. nuclear sector development, licensing, and construction of new commercial nuclear technologies aimed at creating a vibrant U.S. nuclear industry with export opportunities and significant global influence. One of DOE's more recent financial

assistance initiatives aimed at new nuclear technology development was the Nuclear Power 2010 Program (NP2010). This program sought the deployment of new baseload nuclear generating capacity in the U.S. by around 2010 to enhance U.S. energy supply diversity and energy security; a key national energy policy objective. This program led to the design certification and subsequent construction of four (4) AP1000 reactors in China. In addition, two (2) AP1000s under construction in the U.S.

More recently and at the direction of Congress, the DOE in 2012 initiated the Small Modular Reactor (SMR) Licensing Technical Support (LTS) program. The LTS program promoted "the accelerated deployment of more near-term SMRs with improved and advanced safety, operational and security features by supporting certification, licensing, and siting requirements for U.S. based advanced light water SMR projects." The first of two funding opportunity announcements (FOA) under this program focused on projects involving SMR designs that can be expeditiously licensed and achieve a Commercial Operation Date (COD) on a domestic site by 2022. Generation mPower was the sole award recipient under this FOA, but subsequent business decisions ended this contract before completion of the project goals.

A subsequent FOA issued in March 2013 sought applications for SMR designs that offer unique and innovative solutions for achieving the objectives of enhanced safety, operations, and performance relative to currently certified designs. NuScale Power was the sole award recipient under this FOA. This program is continuing with full engagement with the NRC to obtain a Design Certification of the NuScale SMR by 2020.

Finally, the DOE should continue with robust investment in programs like the Gateway for Accelerated Innovation in Nuclear (GAIN) as a mean to continue to drive the advancement in next generation nuclear energy reactor design and build, to include advanced concept ideas like the Thermo, salt, and pebble bed reactor concepts.

Support New Build Initiatives to Speed Development Process

To further strengthen the USG commitment to the SMR and Advanced Reactor technology efforts, the President should recommend funding in the FY21 Defense Request, for the deployment of four or more SMRs in key geographic locations like, Guam, Puerto Rico, Northern Alaska, and other critical areas of operation where disruption of power, or lack of reliable power sources, can threaten U.S. national security. Investment by the DOD would speed operational assessment, and the time to commercial market. It would also provide the necessary validation and credibility of the U.S. SMR technology for the international customer, as defined above. It could also create international demand for the U.S. product.

Utilize Enhanced Financial Vehicles for Technology Development and Deployment

DOE financial assistance for advanced technology opportunities has generally been in the form of cost-share awards. For the more recent funding opportunities noted above, the amount of cost share being borne by each party (i.e., DOE and the applicant) varies with generally the DOE taking more than equal cost share for activities associated with early stage development (i.e., TRLs 1-3) and R&D. As technology development progresses, these cost

share percentage typically adjust to more equal allotments (e.g., 50%/50%). While such financial assistance to U.S. commercial enterprises is very helpful in advancing the technology's development, it is often insufficient. This is due to, for example, appropriations, or dilution of available funds across numerous technologies, or an inability of the recipient to match funding in the amounts needed to bring the technology to commercialization. It is substantially less than the financial support being provided by foreign governments, particularly Russia and China, to their state-owned nuclear technology development companies.

There are currently more than 40 U.S. companies developing new advanced nuclear technologies. Most of these companies are start-up enterprises with limited financial means and are often unable hold an equity position in a first plant project or establishing an owner/operator company as is the case of many of the current large nuclear plant deployments that are being financed and deployed under a build-own-operate-(transfer) model in several international markets. These financial limitations decrease U.S. technology competitiveness internationally and enable technologies from state-owned enterprises to advance in the international commercial marketplace.

As a result of the cancellation of the V.C. Summer Project in South Carolina and the schedule delay and cost overruns at the Vogtle Project in Georgia, U.S. customers and private investors now will only take limited cost, schedule and technology risk associated with first deployments. Their expectation is that USG support is necessary to obtain first-of-a-kind learning and bridge any gap. Therefore, it is imperative that the USG consider increasing and expanding the current forms and amounts of financial assistance it provides towards the development of U.S. advanced nuclear technologies that demonstrate sufficient progress towards overall commercial viability. Increased financial assistance to the technology developer needed to ensure its ability to sufficiently complete the design to the point of being ready for deployment should be considered.

The USG should continue with current levels of involvement helping to de-risk first mover projects while enticing electricity generation developers to pursue new advanced nuclear projects. Support under public-private partnerships and in the form of offering sites at DOE or Department of Defense (DOD) facilities, loan guarantees, production tax credits, joint use module plants ("JUMP") initiatives (as has been recently announced by the DOE in connection with the UAMPS/NuScale Carbon Free Power Project at the Idaho National laboratory) or other similar equity stake positions taken in first plant projects, long term power purchase agreements associated with energy supplies to government installations including under highly resilient and reliable micro-grid arrangements for DOD and other USG mission critical facilities, should continue and be expanded.

Other forms of support that serve to lower the cost of capital, reduce risk associated first-of-a-kind components and perfecting these components, USG-funded demonstration or prototype projects, and USG supported or developed off-grid energy delivery applications are among the types of programs that the USG should consider and expand upon to help ensure successful first plant deployments, and a vibrant U.S. nuclear industry. The Subcommittee believes this all fits well within the new BUILD Act which will allow the USIDFC to make equity investments, provide technical assistance, increase the ability for

industry to take "smart risks", provide a 7-year authorization, create a "preference" for U.S. investors, and increases the USIDFC investment cap to $60 billion.

5. Expand U.S. commercial trade presence in the international market

As mentioned in previous sections of this report, the time is past due for the myriad of capable U.S. government entities to unite with worthy private sector resources to enhance U.S. commercial nuclear presence in global commercial markets. We can no longer afford to let our competitor nations, namely China and Russia, to dominate the global commercial nuclear market.

The subcommittee discussed four key shortfalls related to our current USG global nuclear energy focus:

- **No clear integrated, accountable sustained nuclear energy strategy for global markets**
  Simply put, there is no existing comprehensive governmental nuclear energy trade and promotional strategy.

- **No central coordinating point or one stop shopping for U.S. commercial entities**
  Notwithstanding a myriad cast of capable governmental entities involved in trade promotion, at least in the nuclear energy arena, there is no single point of contact for either commercial trade promotion or for commercial nuclear interests.

- **Myopic focus on developing emerging newcomer country markets**
  Although there are over 30 countries exploring nuclear energy, the U.S. has no developed or coordinated approach or strategy for mid-term promotion and nuclear energy trade business development for emerging newcomer country markets.

- **Functions subject to change with change of Administration**
  Change of Administrations, while not unique to nuclear energy commercial trade in the international market, has contributed to a stop-and-go approach to global markets in some part due to the lack of definition of the value of the nuclear energy markets and a sustainable strategy.

To address some of the aforementioned shortfalls, the subcommittee makes the following recommendations to help expand U.S. commercial energy trade presence in international markets:

Develop innovative ideas, such as energy technology trade missions of which nuclear is a key component. Consider USG implementation of a renewed "Atoms for Peace" program, broadly marketing Advanced Reactors across government agencies, including DOS, DOC, and DOE.

The surge toward American advanced nuclear energy technology with SMRs, Advanced Reactors and Micro-Reactors offers the U.S. a unique window of opportunity for a reset in its commercial trade approach to global markets. Entrepreneurially-driven advanced nuclear

technology provides the potential to technically leapfrog large, capital intensive Sovereign dated technology options with nimbler, more economical, safety advanced commercial offerings with lessened upfront capital requirements. This technology has the potential to disruptive the current global market while allowing a rebranding and retooling of U.S. commercial trade initiatives around advanced nuclear. The time is ripe for the governmental alphabet soup of entities to forge a new nuclear energy trade strategy around advanced nuclear that embraces all-of-the-above US energy technology trade missions including nuclear in nexus markets such as the United Kingdom, Japan, Poland, Africa and South America. Any strategy should consider a modernized "Atoms for Peace" program, which worked successfully for U.S. commercial interests in the 1950s and 60s.

Increase governmental nuclear energy advocacy in concert with national laboratories, universities and industry focused on emerging markets.

Central Europe, Asia, Africa, South America and the Middle East offer opportune nuclear energy trade development prospects in newcomer and emerging nuclear countries. The International Framework for Nuclear Energy Cooperation, administered by the OECD Nuclear Energy Agency, has 34 standing members (some of which are newcomer countries) and 31 observer members, most of which are actively exploring the addition of nuclear energy to their power portfolios. This large number of potential market prospect candidates calls for a coordinated and sustainable program to further future U.S. commercial nuclear trade. This program should emphasis training and education for students and professionals – e.g., future nuclear energy leaders – from near-term market countries and targeted newcomer countries including arenas where hybrid nuclear systems in tandem with renewables are attractive. A program offering should be arranged and supported by the SAP-ENEP and include national laboratory and university assets. Another important collaboration with this offering would include an industry advisory committee which assists in training best practices as business model development for these newcomer markets. Texas A&M's Nuclear Power Institute, which has an intersection of academic, industry and governmental partners, can serve as a model example. This program currently has ongoing programs and special expertise in newcomer country leadership and technical development.

The key to the U.S. success in rebuilding our global role in nuclear energy development and deployments begins with a honed focus on our areas of strength--Education, Security, and Advanced Technology Development.

Continued Investment in Nuclear Science and Engineering Education and Training

U.S. universities and our national laboratories have been, and remain, a top choice for students around the world to be educated, especially in the field of nuclear science and engineering. We need to capitalize on this position and continue to grow investment in the programs that supports our education and training infrastructure. This means continued public and private investment in our universities and laboratories. We need to revitalize our education and training programs for nuclear engineers and operators. A rebirth and growth of the nuclear energy field will provide a solid and long-term career path for many American and international students in this field. Students can be trained and certified to work around the globe in support of the nuclear energy industry. In the near term, this means adjustments

to education visas to allow more foreign national participation in education and training, so we ensure the future nuclear energy global workforce are highly trained in the operations, maintenance, sustainment and safety of running a nuclear energy power plant as required by U.S. standards, which are the most safety conscious and regulated in the world. If the USG were to strengthen educational offerings in nuclear sciences and engineering, it would create the necessary feeder stream for technical workers well into the future. Training the world's nuclear workforce in the United States would have the added benefit of building a cultural and professional relationship with these students while here in the United States and that continues once they return home. Integral to the education and training provided by U.S. institutions comes a respect for nonproliferation, and the value of the peaceful uses of nuclear energy. Our strong academic record in the field of nuclear energy sciences is essential to promoting efforts to address national security concerns, nonproliferation, nuclear regulations, health physics, nuclear safety, nuclear waste disposal and environmental cleanup programs.

Support the creation of the SAP-ENEP to provide a more coordinated, concerted approach.

This avenue could include some or all of the following recommendations:

- Designation of the SAP-ENEP as a "Capture Manager" for U.S. global nuclear energy at the White House
- Creation of a senior level sub cabinet interagency Team USA nuclear exports working group "board of directors" which report to the SAP-ENEP (as mentioned in section 3, this group would include DOE, Commerce, State, Ex-Im Bank, US Infrastructure Development and Finance Corporation) to meet quarterly and provide senior level direction to the Team USA effort. Enhancements to the Team USA campaign should include standing reports to the Civil Nuclear Trade Advisory Committee to gain the benefit of industry input as well as the DOE's Nuclear Energy Advisory Committee.
- Development of a five-year commercial nuclear trade strategy and targets in concert with key stakeholders including industry.
- Looking at the U.S. approach to global military sales as a model for nuclear energy's approach to export markets.

6. U.S. nuclear infrastructure is critical in maintaining global competitiveness and our national leadership in reactor safety, nonproliferation, safeguards and security.

As noted earlier in this report, in order for the U.S. to reclaim the mantle of leadership in the global nuclear energy ecosystem, a robust domestic nuclear industry that is an active participant in all aspects of the nuclear enterprise, including designing and building new nuclear energy plants, developing a comprehensive fuel cycle approach, implementing a viable nuclear waste storage and disposal strategy, and educating and training current and future nuclear scientists and engineers is recommended and required. The Subcommittee made the following recommendations to help achieve this goal.

The DOE Should Expand Role Beyond Early Stage R&D for New Infrastructure

The DOE has an important role to play in revitalizing the domestic nuclear industry. Its role should go beyond the current constraint of early stage R&D, to helping with the initial deployment of new technologies. We applaud DOEs recent announcement that it will build the Versatile Advanced Test Reactor. Doing so, we believe, will demonstrate domestic supply chain capabilities, enhance the development of advanced technologies and excite a new generation of nuclear industry employees.

In addition, the DoE should continue to support efforts related to additive manufacturing that are currently ongoing with BWX Technologies, and Oak Ridge National Laboratory (ORNL). Additive manufacturing will allow the creation of complex designs that can be rapidly prototyped and tested. This will allow these new components to be fabricated in the U.S., and significantly reduce the time and money it will take DOE to bring new fuels and components to market

Increase Funding for Nuclear R&D to Enhance U.S. Manufacturing Capability

We also believe that DOE should seek increased funding for nuclear R&D to revitalize the nuclear capabilities at the national laboratories and at colleges and universities nationwide. Concomitant with this should be a significant increase in funding for workforce development, including grants and fellowships, at both the professional and craft levels. This will incentivize capable individuals to consider nuclear energy as a viable career path and provide colleges, including community colleges, the resources needed to build strong, sustainable, programs. We recommend that DOE, working with other federal agencies and with industry, invest in efforts to regain U.S. advanced manufacturing capabilities. This will be an expensive endeavor, but it can have an important impact not only in civilian nuclear energy but also in other areas of national security importance, including the U.S. Navy's fleet of nuclear-powered ships. As commented on in other sections of this report, the recent passage of the BUILD Act will help with this goal. The funding provided by the BUILD Act, and the creation of a SAP ENEP would help this effort immensely.

DOE has recently funded a program to regain domestic uranium enrichment capabilities. This is an important step that should provide some assurance that the fuel needed for advanced reactor systems, and other domestic nuclear imperatives, will be met. It is equally important that steps be taken to demonstrate solutions to the entire fuel cycle, including the back-end activities. This includes permanent geologic waste disposal and long-term consolidated dry spent fuel storage.

Regain Indigenous U.S. Uranium Enrichment Capability

The Subcommittee recognizes the importance for an indigenous enrichment capability in the United States. The recent announcement that the Urenco USA facility in New Mexico will start producing High Assay Low Enrichment Uranium (HALEU) is a welcome step but one that, we believe, does not replace the need for an all U.S. capability.

The Subcommittee understands there is a delicate balance to be struck between investment in uranium enrichment in the U.S. and the need to continue to robustly fund our college and university R&D and education and training programs. This is not an either/or decision, it is

imperative the USG invest in both. Therefore, the Subcommittee encourages the DOE to provide policy and funding support for enrichment projects in the U.S. Two projects come readily to mind, the Urenco USA enrichment effort planned at the Eunice, New Mexico, and efforts by DOE to invest in the Centrus Energy Corp production facility in Piketon, OH. As we continue to invest and build our technology readiness for new advanced reactor concepts, we will need access to reliable sources of HALEU. A demonstrated commitment by the DOE and the White House will be essential.

The International Subcommittee shares in the concerns about the budget cut to the NEUP expressed by the Fuel Cycle and Existing Facilities Subcommittees. Understanding the need for the DOE to find funding for the Centrus project, we recommend the DOE finds other reprograming options within the FY19 and FY20 budgets to bolster the NEUP funding as well. As stated in the FY2019 Funding Opportunity Descriptions, the DOE office of Nuclear Energy has three key priorities: 1) Enhancing the long-term viability and competitiveness of the existing U.S. reactor fleet; 2) developing and advanced reactor pipeline; and, 3) Implementing and maintaining the national strategic fuel cycle and supply chain infrastructure. Adequate NEUP funding is a key component of achieving all three of these priorities. As mentioned in the Fuel Cycle Subcommittee report, other options to obtain HALEU should also be pursued.

Demonstrate Solutions to Permanent Spent Fuel Disposal and Long-Term Dry Storage

The USG through DOE has invested many billions of dollars and decades in the development and construction of the Yucca mountain geologic waste storage facility. From a purely technical perspective, the resulting structure, while not perfect, provides a suitable place to start storing spent nuclear fuel. DOE is strongly encouraged to continue pursuing the licensing of Yucca Mountain (and developing incentives for the state of Nevada to allow this site to be completed), while at the same time aggressively working with receptive communities that would willingly develop an interim dry spent fuel storage facility. This type of dual approach effort could demonstrate U.S. leadership in this important nuclear fuel cycle area. It would also provide excellent R&D opportunities for international collaboration in spent fuel storage and disposition.

7. International Collaboration

As mentioned throughout this report, historically the U.S. has been the global nuclear energy partner of choice. We had the best and safest technologies, the best companies, generous export financing, the best national laboratories, the most welcoming colleges and universities, the clearest policies and we strongly encouraged countries to enter the civilian nuclear market with appropriate nonproliferation constraints and embraced partnerships. We also had a growing civilian nuclear energy complex with the largest number of operating nuclear plants in the world. Nuclear energy was a strategic imperative for the U.S. It was a tool for building alliances and for supporting energy independence in developing countries. The International Subcommittee believe it is time we return to these roots.

The United States must reverse the global opinion that we are no longer the best in many areas. For example, there are no U.S. fully-owned commercial nuclear reactor suppliers left.

General Electric continues to do nuclear business in a partnership with Hitachi. Westinghouse is fully owned by a Canadian firm, Brookfield Business Partners.

In order for the U.S. to get fully back in the game we need a very different approach. The Subcommittee's recommendations are as follows:

Identify and Develop Strategic Global Relationships

We need to identify and develop relationships with potential commercial customer countries well in advance of any projected sale of nuclear technology. The factors involved in identifying these countries should include geostrategic and national security considerations, industrial capabilities, and market potential. These relationships should go well beyond nuclear energy to encompass other energy sources such as solar, wind, geothermal, natural gas, and hybrid energy.

Develop Broad International Nuclear Energy Marketing Strategy

The U.S. should develop a broad marketing approach to commercial exports that recognizes its national security dimensions. Energy security is one, while reliable smart grids could be another. This approach should include robust offerings of meaningful activities with our national laboratories and colleges and universities. This approach should also include early engagement through U.S. products and services, as appropriate. These could include accident tolerant fuels, advanced digital instrumentation and controls, and back-end spent fuel storage options.

Engage in New Partnerships with Selected Nuclear Countries

The U.S. should intensify its work with other advanced nuclear nations, such as Japan and the Republic of Korea. This could include joint international projects and enhanced working relationships with other export credit agencies on joint international projects.

If the United States is to get back to a position of strength in the civilian nuclear energy arena, the U.S. must treat this as a national security imperative. Without this kind of positioning, it is likely that U.S. key national priorities, such as nonproliferation, nuclear safety, and security, will take a back seat to the priorities of other nuclear exporters. It is highly likely that these priorities, especially in the case of Russia and China, will not completely align with our own.

8. Develop and Deploy Communications Messaging – Possible Themes

The U.S. Department of Energy Office of Nuclear Energy is working to strengthen domestic energy security, advance U.S. economic prosperity, and ensure global security through U.S. nuclear science and technology leadership. Ultimately, the Office of Nuclear Energy seeks to revive, revitalize and expand the Nation's nuclear energy enterprise to realize the enormous potential of nuclear energy. An important part of this goal is to have an effective communications strategy.

Nuclear energy is currently the subject of serious discussion and debate in the context of current and future energy strategy both domestically and internationally. Recent U.S. Congressional actions in support of nuclear technology have been enacted into law. This is

due to the fact that advanced nuclear technologies are being recognized as having the potential to play a leading role in providing emission-free energy (both electricity and process heat) and can be integrated well into future energy infrastructure to make a major reduction in carbon emissions across many industrial sectors. Advanced nuclear technologies are being recognized for their capabilities and attributes that allow them to be integrated into hybrid energy applications supporting broader energy needs in addition to electricity generation such as; production of hydrogen, treatment and purification of water, process heat supply and integration with new and evolving energy technologies.

The Subcommittee recommends the DOE hone four key message themes over the next year that go beyond or complement what it has already been doing:

- Nuclear Energy is a Clean Green Environmentally Friendly Source of Energy
- Nuclear Energy is Affordable and Reliable
- Nuclear Energy is Safe and Advanced Technologies Continue to Make it Safer and More Affordable to a Broader Range of Global Customers
- The United States Government is Fully Supportive of the Commercial Nuclear Energy Industry in the U.S.

The Office of Nuclear Energy (DOE-NE) has an ongoing communications effort in place with the goal of education and awareness of today's nuclear technology and the benefits to society that could be bolstered. The DOE-NE communications program currently focuses on the following messages in various channels:

- "101 – the Basics" of nuclear technology for education
- Nuclear Innovation/Technology (as it applies to Existing Fleet and Advanced)
- Safety Innovation (as it applies to Existing Fleet and Advanced)
- Advanced Reactors including SMRs and Micro Reactors
- Impact of Declining Existing Fleet
- Economic Value of Advanced Reactors

These, and other messages, are included in the following five main outreach channels:

Broad Audience

An ongoing social media effort that includes infographics, short video vignettes and blogs provide education and engagement about the programs and applied research in nuclear technology to a broad national and international audience. This effort also includes participating in events such as Earth Day, Nuclear Science Week, a YouTube Channel, Linked In, Facebook and Instagram.

Millennial/Young Adult Audience

DOE-NE has designed a series of in-person and on-line events in a series called Millennial Nuclear Caucuses, designed to engage conversation with young adults on the topic of nuclear energy and how it can contribute to a clean energy future and jobs. In addition to the Millennial Nuclear Caucuses, in 2019 DOE-NE is developing a new series called "Clean Energy

Dialogues" to be held on college campuses to engage students who are environmentally motivated. These events are sometimes international in focus, including events held at:

- The Pacific Basin Nuclear Conference (San Francisco, CA, Sept. 2018),
- Tokyo Institute of Technology (Tokyo, Japan, Nov. 2018), and
- IAEA Conference on Climate Change and Nuclear Energy (Vienna, Austria October 2019).

Greater partnering with like-minded nations and international organizations could amplify DOE-NE's messages.

K-12 Curriculum

DOE-NE is partnering with the American Nuclear Society and the Discovery Channel Education Network to provide nuclear energy education in more than 50% of the school systems in the United States for elementary, middle school and high school.

Congressional/Legislative

Hold monthly "Atomic Wings Lunch & Learn" on Capitol Hill with topics include SMRs, Advanced Fuels, Private-Public Partnerships, Nuclear Powering NASA, Micro Reactors, and more. Typical attendance is roughly 150, including staffers, members, industry, universities and embassy staff.

Industry

DOE-NE staff speaks at industry events and promotes the communications channels of the NE e-newsletter and social media channels.

These efforts are primarily domestic in focus, but can be used to help promote the idea that nuclear is clean and innovative and highlight future events.

<u>Upcoming Potential Communications Opportunities</u>

Some recent events or achievements may provide significant opportunities for increased communications engagement. For example,

Recent Enactment of the Nuclear Energy Innovation Capabilities Act of 2017

This bill was signed into law in September of 2018 and includes several opportunities for increasing engagement and awareness of nuclear energy. In addition to a number of actions, the law authorizes establishing the Nuclear Reactor Innovation Center and requires consideration of establishing a versatile neutron source in the United States. As DOE acts on many of the directives established in the NEICA legislation, communication activities will play a significant role both domestically and internationally.

Nuclear Innovation Clean Energy (NICE) Future Initiative

The NICE Future initiative was established under the Clean Energy Ministerial (CEM) in 2018. This international initiative offers the opportunity to highlight the beneficial aspects of nuclear energy as a non-carbon emitting source of energy to the international and

domestic communities. DOE-NE could look to broaden its involvement in international events at meetings of the International Framework for Nuclear Energy Cooperation (IFNEC), and at the IAEA. Key facets of this initiative to be highlighted are the possible opportunities for developing integrated nuclear-renewable energy systems for the future and small modular reactors.

Water Security Challenge

The Secretary of Energy announced the Water Security Challenge in the Department of Energy on October 25, 2018. This effort seeks to work across government and industrial organizations to establish goals and challenges that by 2030 achieve dramatic results in improving energy and water resource generation and utilization. Use and production of water and energy are intimately tied together in our social, economic, and political fabric. As our populations and societies advanced and grow so will our demand for energy and water resources both domestically and internationally. This topic represents an excellent opportunity to highlight and raise the awareness of the beneficial attributes that nuclear energy can bring to the energy and water sectors.

Appendix A – NEAC International Subcommittee Meeting Agendas (October 18-19, 2018 & January 10-11, 2019)

Agenda
NEAC International Subcommittee Meeting
October 18-19, 2018
Washington DC

DOE Headquarters Forrestal Building (Atoms for Peace Conference Room 5A-118)

Thursday, October 18

Start Time	Topic	Presenter
9:00 am	Welcome and Introduction of Participants	Regis Matzie & Lisa Marie Cheney
9:15 am	Review of International Subcommittee Charter	Lisa Marie Cheney
9:30 am	Review of past recommendations by Subcommittee and what is different now	Regis Matzie
10:00 am	Briefing by DOE NE on Administration initiatives to help U.S. competitiveness in global nuclear market	Ed McGinnis
10:30 am	Current NE-6 Activities and Initiatives	Sarah Lennon
11:00 am	Discussion of U.S. nuclear innovation and global leadership status/position	All
11:30 am	Discussion of U.S. large reactor vendor status and potential to be successful in global market	All
12:00 pm	Break for lunch	
1:00 pm	Briefing by DOE on SMR and Advanced Rx Strategy	Tom O'Connor
2:00 pm	Leadership in nuclear energy at our national nuclear laboratories and universities; how can this be leveraged	Mike Goff
2:45 pm	Briefing by CINTAC on barriers to U.S. global competitiveness with discussion	David Blee
3:30 pm	Briefing by NuScale on what DOE and the USG can do to help promote U.S. global competitiveness	John Hopkins
4:15 pm	Potential for collaboration with international partners (e.g., South Korea or Japan)	Allen Sessoms & Sarah Lennon
5:00 pm	Adjourn	

Friday, October 19

9:00 am	Briefing by Ex-Im Bank with discussion	Geoffrey Jones
10.00 am	Briefing by NEI on barriers to U.S. global competitiveness with discussion	Dan Lipman & Ted Jones
11:00 am	Open discussion on findings and way forward	All
12:00 pm	Adjourn	

AGENDA
NEAC International Subcommittee Meeting
January 10-11, 2019
Washington, DC

DOE HQ Forrestal Bldg. - 1000 Independence Ave., S.W. Washington DC - Room 4A-104
Teleconference number (415) 527-5035 – Attendee code 15535301

Thursday, January 10, 2019

Start Time	Topic	Presenter
9:00 am	Opening Remarks	Ed McGinnis
9:15 am	Introductions and review of the draft outline for final report	Regis Matzie (Chair – NEAC)
9:45 am	SWOT analysis of U.S. nuclear competitiveness in the international market (Verdigris Capital)	Walter Howes & Andrew Paterson
11:00 am	BREAK	
11:15 am	SWOT analysis (continued)	
12:30 pm	LUNCH	
1:30 pm	Joint Study by NREL and INL on how SMRs can complement renewables	Shannon Bragg-Sitton (INL)
2:30 pm	NICE Future Initiative under the Clean Energy Ministerial	Sarah Lennon (DOE)
3:30 pm	BREAK	
3:45 pm	Utility views on attractiveness of U.S. nuclear offerings	Marilyn Kray (Exelon)
4:45 pm	Committee Discussion on what was learned	
5:00 pm	Adjourn	

Friday, January 11, 2019

9:00 pm	Remarks	Regis Matzie
9:15 pm	Draft final report to NEAC	All
12:00 pm	Adjourn	

Appendix B – International Subcommittee of the NEAC – Charter

Charter
International Subcommittee of
Nuclear Energy Advisory Committee (NEAC)

Office of Nuclear Energy
U.S. Department of Energy

Purpose:

The purpose of the International Subcommittee is to provide expert advice and guidance to the Assistant Secretary for Nuclear Energy, through the Nuclear Energy Advisory Committee (NEAC), on international nuclear energy policy which aims to support U.S. competitiveness in the global nuclear energy market and reestablish the Nation's historic leadership in the field thereby ensuring the safe, secure and peaceful expanded use of nuclear energy in a manner that minimizes the risks of proliferation. As nuclear energy continues to expand internationally, U.S. leadership is being significantly challenged by countries such as Russia and China and their state-owned nuclear entities. State sponsorship, attractive financing options, human resource development and bundled services, such as fuel takeback, are helping these countries achieve a significant competitive edge over U.S. nuclear vendors. Therefore, it is critical to consider every possible option to revitalize and expand the U.S. nuclear industry presence and its global leadership.

International nuclear energy policy also includes efforts to build and strengthen reliable international nuclear fuel service arrangements, international nuclear energy infrastructure development, nuclear commerce, and bilateral and multilateral efforts that help further U.S. strategic policy objectives. Other topical areas for review can be added by the Assistant Secretary for Nuclear Energy. The subcommittee shall report to NEAC and function in accordance with the Federal Advisory Committee Act (FACA).

Objective:

The primary objective of the International Subcommittee is to provide independent expert advice and guidance related to opportunities for improving U.S. competitiveness in the global nuclear energy market and reestablish the Nation's historic leadership in the field and review related activities within the Office of Nuclear Energy and report its findings, recommendations, comments, and guidance to NEAC and the Assistant Secretary for Nuclear Energy.

Subcommittee Membership:

The Chairs of each subcommittee shall be a member of the full committee. The Chair and Co-chair of NEAC are ex officio members of the subcommittee. The Chairs of the International Subcommittee shall propose NEAC members to serve on the subcommittee, who will be jointly approved by the Assistant Secretary of Nuclear Energy and the NEAC Chairs. The Subcommittee Chairs can propose non-NEAC members to service if such

persons provide an expertise that is not available in the NEAC member pool, however, members should have expertise in international fuel cycle policies and activities, international nuclear energy infrastructure development, nonproliferation, and technical expertise in nuclear reactor and fuel cycle technologies.

Meetings, Reports, and Other Matters:

The Chairs of the International Subcommittee shall determine when and where the subcommittee will meet. Attendance at subcommittee meetings is by invitation of the subcommittee Chairs only. It is expected that the subcommittee will meet no less than once in any 12-month period and the Chairs will report on the subcommittee's activities to NEAC at their normal meetings. It is also expected that a brief report will be generated after every subcommittee meeting documenting the meeting. The brief report will be provided to the NEAC Designated Federal Officer within 30 days of the meeting for distribution to the full committee. The subcommittee's report to NEAC can be presented by the Chairs or the subcommittee Chairs may delegate that responsibility to one of the subcommittee members. This decision is at the sole discretion of the subcommittee Chairs. Subcommittee documents (e.g., presentation material) will be made available to members of the full committee upon request.

Appendix C – Major New Nuclear Legislation

S.512: Nuclear Energy Innovation and Modernization Act (NEIMA) **(Law)**

NEIMA's focuses on modernization of the NRC's regulatory framework to provide clarity and predictability for advanced reactor license application. The bill has measures to reduce regulatory costs and to incentivize the NRC to develop a modern, technology neutral framework that allows for phased and expedited licensing of quickly emerging, game-changing advanced nuclear energy technology. By reforming outdated laws, NRC will now be able to invest more freely in advanced nuclear R&D and licensing activities. This in turn will accelerate deployment of cutting-edge American nuclear systems and better prepare the next generation of nuclear engineers and technologists.
https://www.congress.gov/bill/115th-congress/senate-bill/512

S.3422: Nuclear Energy Leadership Act (NELA) **(Not enacted yet)**

This bill would direct the Secretary of Energy to advance the R&D of domestic advanced nuclear energy by demonstrating various advanced nuclear reactor technologies that could be used by the private sector; develop a 10-ear strategic plan for the Office of Nuclear Energy that supports advanced nuclear R&D goals; provide for a versatile test reactor by 2025; establish an advanced nuclear fuel security program to make available high-assay low enriched uranium for use in commercial or noncommercial advanced reactors including for initial fuel testing, operation of a demonstration reactor, and their commercial operation; and directs DOE, NNSA, and the NRC to establish a program to support the development for the high-skilled workforce needed to develop, regulate, and safeguard advanced reactors. Finally, the bill would extend long-term power purchase agreements from 10 years to 40 years; and authorize a pilot program for the federal government to enter into a nuclear power purchase agreement that exceeds 10 years for new technologies that increase electric reliability and resilience, in particular for assets critical to national security.
https://www.congress.gov/bill/115th-congress/senate-bill/3422?q=%7B%22search%22%3A%5B%22S.3422%22%5D%7D&s=1&r=1

S.97: Nuclear Energy Innovation Capabilities Act of 2017 **(Law)**

This bill authorizes DOE to support the research and development of advanced reactor technologies. It also directs DOE, if needed, to build by 2025 a versatile reactor-based fast neutron source to support research and development of advanced reactor systems.
https://www.congress.gov/bill/115th-congress/senate-bill/3422?q=%7B%22search%22%3A%5B%22S.3422%22%5D%7D&s=1&r=1

Appendix D – U.S. Global Competitiveness Strengths, Weaknesses, Opportunities, and Threats (SWOT) Analysis

The strengths of the U.S. nuclear enterprise are in the performance of the U.S. domestic operating fleet, which has consistently been in the range of 90% capacity factor for decades; the regulatory framework encompassed by the NRC, which is viewed as the "gold standard" globally; the innovation demonstrated in the U.S. private sector in the areas of advanced reactor designs, advanced fuel forms, etc.; the U.S. university science and engineering programs, which bring a large number of foreign students each year to steady with the best professors; and the U.S. national laboratory complex, whose R&D capabilities are unequaled by others.

The major weaknesses of U.S. global competitiveness are the premature closure of some of the operating reactors, which harms U.S. reputation overseas while reducing the U.S.'s ability to properly address climate change; the lack of a capability to "take-back" used fuel from an emergent nuclear energy nation; and the performance of U.S. vendors in new reactor build.

The threats and challenges to our success overseas are many, but are highlighted by the lack of success building new reactors in the U.S.; the non-competitive nature of U.S. financing options compared to those of China and Russia primarily; the bids of international state-owned-enterprises, which can take advantage of their countries' geopolitical strategies; and the potential of another major reactor accident anywhere in the world, which can be highly disruptive to new build plans everywhere.

The opportunities that the U.S. must take advantage of if it is to reestablish our global leadership are potential new market niches that are presented by integrated/hybrid nuclear energy systems working with renewable energy sources; the drive in many countries for energy sources that address clean air and global climate change; the strong interest now unfolding worldwide in potentially viable advanced and micro-reactor technologies, including LWR SMRs, that can address specific energy needs in ways that large LWRs cannot.

The actual SWOT analysis tables that show both the highest-ranking activities for U.S. global competitiveness of the U.S. nuclear energy enterprise as well as the less important activities are shown below.

	Ratings for U.S. Nuclear Energy Enterprise	**U.S. Global Competitiveness**
	STRENGTHS	
S1	U.S. nuclear fleet: High Performance on largest fleet globally (99GW)	5
S2	International respect for U.S. NRC Regulatory process	5
S3	U.S. private sector technology innovation	5
S4	U.S. university science and engineering programs	5
S5	U.S. National Laboratory capabilities	5
S6	Multi-national supply chain (global reach)	4

S7	High caliber U.S. suppliers for high quality components and sub-systems	4
S8	History of technology transfer to foreign customers	4
S9	Utility R&D through EPRI	3
S10	Ability to localize construction and operations in foreign countries	3

Rating of importance of Factor to Major NEAC Priority (US Global Competitiveness): 5=High, 1=Lower

	WEAKNESSES	**U.S. Global Competitiveness**
W1	Premature closure of U.S. reactors (harms U.S. reputation overseas)	-5
W2	U.S. does not offer "Take Back" of fuel on international bids	-4
W3	Performance to date on new nuclear builds	-4
W4	Limited domestic fuel cycle capability	-3
W5	Lack of resolution on back end Used Fuel Disposition	-3
W6	No U.S. utilities leading international bids (like EDF, Rosatom, KEPCO)	-3
W7	Cost, schedule and uncertainties of NRC licensing for Advanced Reactors	-3
W8	Lack of large components and forging fabrication capability	-3

	Ratings for U.S. Nuclear Energy Enterprise	U.S. Global Competitiveness
	THREATS / CHALLENGES	
T1	Performance to date on new nuclear builds	-5
T2	Foreign Export Credit Agencies more effectively support rival bids	-5
T3	Foreign state-owned enterprises bid based on geopolitical strategies	-5
T4	Another major reactor incident occurs (i.e. like Fukushima)	-5
T5	U.S. is late to the emerging markets	-4
T6	Nuclear is not widely recognized as clean energy	-3

Rating of importance of Factor to Major NEAC Priority (US Global Competitiveness): 5=High, 1=Lower

	OPPORTUNITIES	U.S. Global Competitiveness
O1	Hybrid Nuclear Systems working with renewable energy sources expand possible market niches	5
O2	Clean air/global climate driven demand	5
O3	Advanced and micro-reactor opportunity unfolding worldwide	5
O4	Growth of mega-cities and electrification globally, requiring more reliable electricity supply 24/7	4
O5	More electric vehicles raising demand in transport market	4
O6	U.S. nuclear engineering education providing early engagement to foreign sales	4
O7	Increased desalination will intensify demand	3
O8	International interest in U.S. regulatory regime	3
O9	Replacement power systems in Europe (old nuclear, or baseload fossil)	3
O10	Forming multi-national alliances on bids (foreign policy advantage)	3

Appendix E – Major Export Control Agreements

123 Agreements for Peaceful Cooperation – Section 123 of the U.S. Atomic Energy Act requires the conclusion of a country specific agreement for significant transfer of nuclear material, equipment, or components from the U.S. Section 123 Agreements are important tools in advancing U.S. nonproliferation goals. The agreements also allow for cooperation in other areas such as technical exchanges, scientific research and safeguards discussions. The United States has Section 123 Agreements in place with 22 countries, EURATOM, the IAEA, and Taiwan. Many countries that are developing new nuclear programs do not have Section 123 Agreements, which closes the market to U.S. reactor sales and sales of major nuclear components.

810 Authorizations – Part 810 of Title 10, Code of Federal Regulations implements paragraph 57.b (2) of the Atomic Energy Act for authorizing the transfer of unclassified nuclear technology and assistance to foreign countries on the peaceful uses of nuclear energy. DOE grants these 810 authorizations, with the concurrence of the Department of State (DOS) and after consulting with the Departments of Defense and Commerce and the NRC. These authorizations apply to technology transfers and assistance related to nuclear fuel cycle activities, commercial nuclear power plants, and research and test reactors. The need for country-specific 810 authorizations, and in some cases inconsistent treatment of countries, e.g., Norway, Mexico, Ukraine, and Chile, add to the burden of companies trying to undertake civil nuclear business overseas.

110 Agreements – Part 110 of Title 10, Code of Federal Regulations establishes licensing requirements for any person that seeks to import or export NRC-controlled nuclear equipment or material, including power reactors and their especially designed components.

Appendix F – Ex-Im Bank Competitiveness and Nuclear Experience

EXIM
EXPORT-IMPORT BANK OF THE UNITED STATES

Economic Impact

ECONOMIC SECURITY | EXIM EXPORT-IMPORT BANK OF THE UNITED STATES | NATIONAL SECURITY

Supports American jobs:

- EXIM Bank is a competitive tool in supporting the President Trump's America First agenda to keep jobs in the U.S.
- EXIM provides financing support to foreign buyers to purchase exports containing high levels of U.S. content.
- Over the last ten years, the Bank has supported more than 1.2 million private-sector American jobs.

Enables U.S. exporters to compete internationally:

- EXIM levels the playing fieldfor U.S. exporters in today's brutally competitive and state-subsidized global economic environment.

Counters aggressive foreign competition:

- More than 100 other export credit agencies (ECAs) compete on behalf of their country's exporters around the world.
- Japan and Korea have more than $250 billion in current long-term MLT exposures; Europe and Canada have nearly $300 billion in medium- and long-term exposures (MLT). China has an estimated $500 billion in exposures.
- EXIM currently has $50 billion in MLT exposures.

Does not compete with the private sector:

- EXIM fills export financing gaps through its loan, guarantee, and insurance products for transactions that are creditworthy but not bankable by the private sector.
- "Crowding in" versus "crowding out:" EXIM has enabled a greater level of commercialization of aircraft financing since the global financial crisis.
- EXIM completed a $1 billion aircraft reinsurance program with the private sector in 2018.

Is not "corporate welfare:"

- EXIM does not provide any form of "free" grants and responds to demand from the marketplace.
- The Bank does not pick "winners and losers" and is open to applications for export financing from all sizes and types of companies.
- The Bank does not discriminate against or promote any industry sector.
- The Bank's financing products – export credit insurance, working capital loan guarantees, and foreign buyer financing (typically loan guarantees) – require full repayment and charge fees and interest based on risk.

(over)

EXIM
EXPORT-IMPORT BANK OF THE UNITED STATES

Economic Impact

Protects the U.S. Supply Chain:

- Large U.S. companies (GE, Boeing, Caterpillar) are increasingly utilizing financing from non-U.S. ECAs and shifting their production and supply chains to meet content requirements.
- EXIM's financing of large U.S. exporters provides essential support to the hundreds of smaller companies that serve as suppliers to major exporters.
- EXIM's absence hurts industries indirectly supported by the Bank, such as trucking, shipping, and ports.
- EXIM assists the export of American capitalism and business ethics, as well as products and services.
- Multiplier effect: Each program, project, or individual export creates potential future demand for these U.S. exports.
- Helping the large companies to win sales abroad enables them to maintain their production and jobs in the United States and also preserves the U.S. supply chain.

Directly supports small business:

- Small business exporters need greater risk protection to tackle new markets, grow, and create more jobs.
- The private market cannot support small businesses efficiently or profitably.
- In both FY 2017 and FY 2018, more than 90 percent of EXIM's transactions were for American small businesses.
- EXIM supported more than 3,000 small businesses in FY17 and FY18.

Delivers for the American taxpayer:

- The Bank has generated more than $15 billion for U.S. debt reduction since 2000.
- EXIM has had a default rate of less than one percent for more than a decade.
- The Bank has supported more than 1.2 million American jobs over the last ten years.

Offsets the Chinese Belt & Road Challenge:

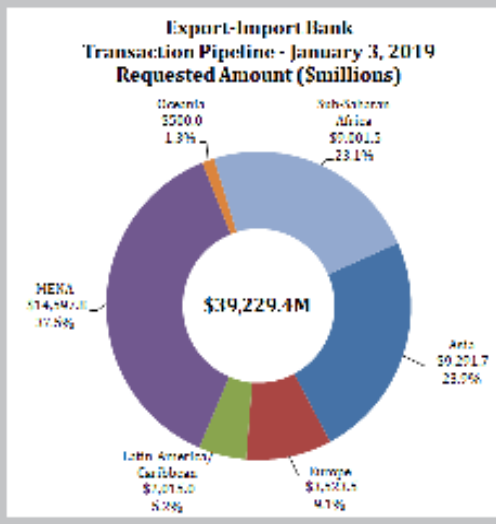
- EXIM helps maintain critical manufacturing infrastructure and key developing industries (robotics, satellites, aircraft, medical devices).
- The Bank supports high-paying manufacturing, engineering, and logistics jobs.

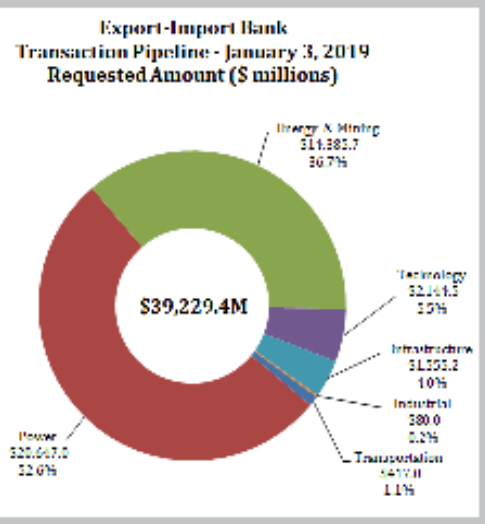
(over)

Economic Impact

Current EXIM Pipeline — as of January 3, 2019:

- EXIM has 39 transactions in its pipeline.
- The transactions represent nearly $40 billion in U.S. exports.
- They would support an estimated 237,000 jobs.

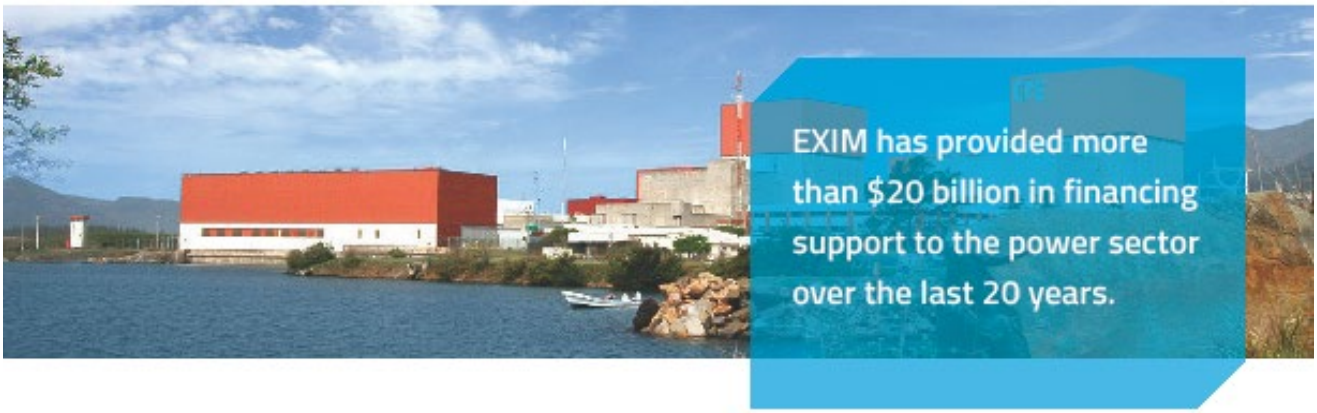




Updated: January 11, 2019

EXIM
EXPORT-IMPORT BANK OF THE UNITED STATES

Nuclear Industry



- EXIM is a critical financial component for the future success of the U.S. nuclear industry.
- This is a credit-worthy but not bankable sector.
- Government-sponsored financing is essential. Projects can require up to $50 billion.

TRANSACTIONS IN PIPELINE

As of October 2018, EXIM has $20 billion in applications undergoing due diligence in the power sector, including nuclear projects. EXIM is currently reviewing three nuclear projects in Asia, the Middle East, and Europe.

Ministry of Finance / Kovvada (India)

In June 2016, EXIM received an application for $8.9 billion to finance various goods and services supporting the construction of a new nuclear power plant project and associated facilities located in the Southeast region of India. The total project cost is $21.2 billion. The project will be comprised of six Westinghouse AP 1000 nuclear reactor power generating units, with a combined gross capacity of approximately 6,600 megawatts.

Kingdom of Saudi Arabia

In November 2017, EXIM received an application requesting $7.6 billion in financing to support the acquisition of various U.S. goods and services for the construction, operations, fueling, and decommissioning of a new nuclear power plant project in Saudi Arabia. The application is different from most nuclear project applications because it requests, not only design and construction but also operations, fueling, and decommissioning. A U.S. consortium led by WEC Energy Group in Milwaukee along with Exelon (operator), Fluor (contractor), GE (supplier) and other U.S. companies, is being proposed. This U.S. consortium is competing with foreign bidders from Russia, China, Korea, and France.

Updated: January 11, 2019

Appendix G – Versatile Advanced Test Rector Program

Versatile Advanced Test Reactor (VATR)

For the United States to regain a global leadership role in development of the next generation of advanced reactors, a fast spectrum test reactor may be an important experimental tool. Advanced reactors are key in providing a diverse portfolio of energy supply sources to ensure national security through energy independence and energy dominance. Advancements in the area of testing of fuels and advanced materials, such as long-life structural and cladding materials, in an extreme environment, can further facilitate their development. Due to the very high neutron flux provided by such a test reactor, the irradiation time for testing of new materials could be reduced by an order of magnitude compared to that for a standard thermal spectrum test reactor such as the Advanced Test Reactor at Idaho National Laboratory (INL). While a decision whether or not to deploy an advanced fast spectrum test reactor has not been made, such a reactor could accelerate innovation in advanced fuels and materials for U.S. vendors and help pave the path to U.S. global leadership in advanced nuclear R&D by reestablishing this capability. Overall, R&D infrastructure is a cornerstone for advancing the technologies needed to revive and expand the nuclear sector in the United States.

China, Russia, France, South Korea, India and Japan are pursuing the development and demonstration of advanced reactors. A key element of their strategy is the ability to accelerate the development and testing of very advanced materials and fuels by testing them in extreme environments, specifically, testing them in very high flux neutron fields. A VATR with a high fast neutron flux can provide the United States this key experimental capability. Engaging with the U.S. industry and linking it with the national laboratories' unique knowledge in the area of advanced instrumentation and "Big Data" analysis, would position the United States to effectively compete and play a leadership role in the international market.

If the United States foregoes the ***timely*** development and commercialization of advanced reactors, other supplier nations will assume future nuclear technology leadership and will engage in the export of their systems. In addition to the adverse economic impacts, this scenario would adversely impact United States' interests in nuclear safety, security and nonproliferation.

The VATR program is utilizing expertise from the national laboratories, universities and industry. In FY 2017, a multi-laboratory team with university and industry participation was assembled to begin work on developing the capability requirements and technical details for versatile advanced fast test reactor concepts. In FY 2018, the needs analysis and capability requirements were completed and work continued for specifying the technical attributes of a potential reactor.

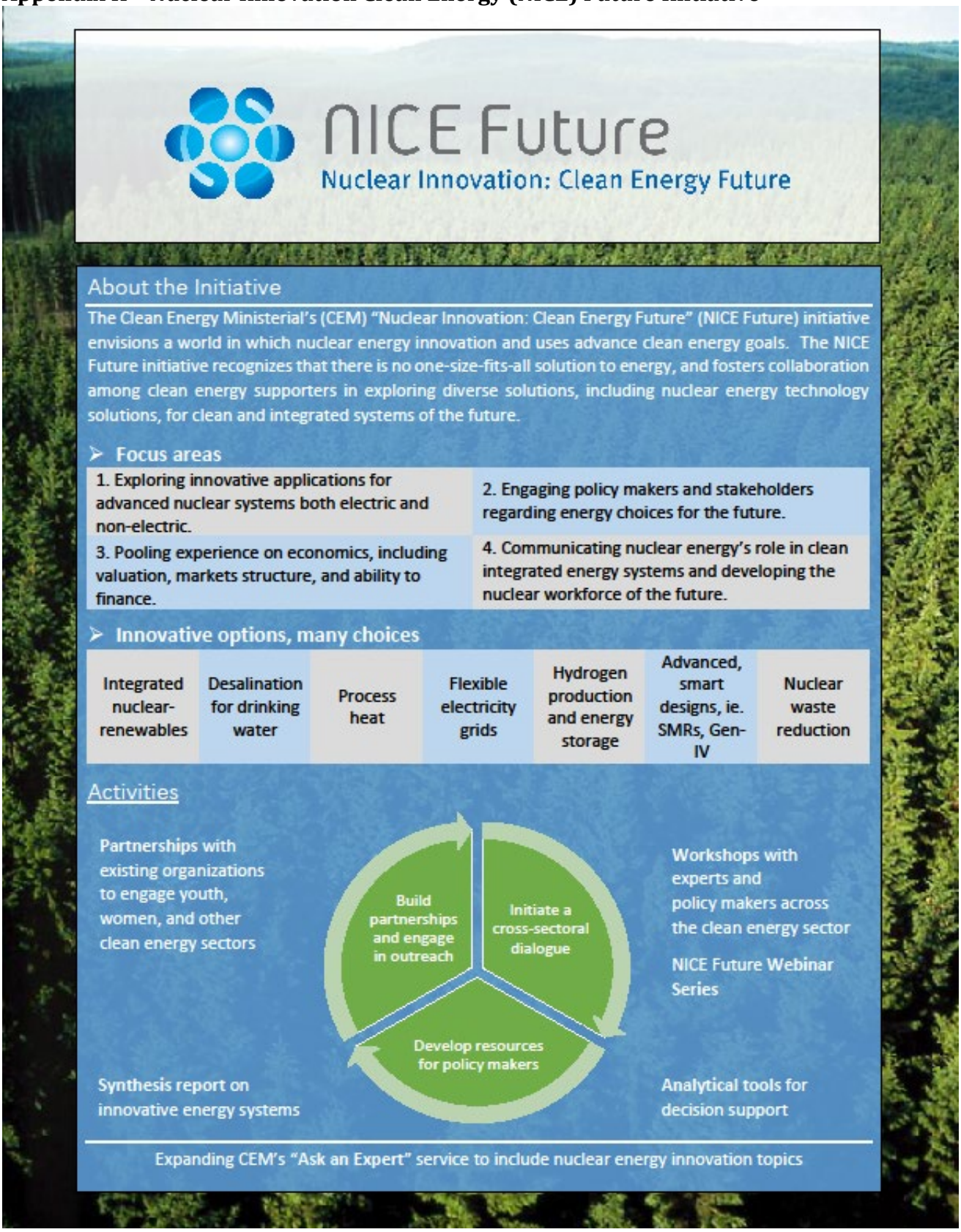
Recently a subcontract was established by INL with a GE-Hitachi and Bechtel team to leverage an existing design concept to develop a credible cost and schedule estimate. Additional industry subcontracts have been established by INL to support the experimental vehicle development for different fast reactor technologies: Gas-Cooled (General Atomics), Molten-Salt Cooled (TerraPower), Lead-Cooled (Westinghouse), Sodium-Cooled

(Framatome), Data Analytics (Hierarchical Data Format (HDF) Group), Structural Materials (EPRI), Virtual Design & Construction (General Electric-Hitachi). Several university awards have been made and a few more are planned in FY 19 to support development of experimental capabilities in the VATR. Universities contributing to this area currently include University of Wisconsin Madison, University of New Mexico, University of Utah, University of Idaho, North Carolina State University, Oregon State University, Abilene Christian University, Colorado School of Mines, Georgia Tech, MIT, Texas A&M University, and University of Pittsburgh.

There is strong bi-partisan support for the VATR Program in Congress. For FY 2019, Congress appropriated $65M for research and development to support efforts to develop the versatile fast test reactor. In addition, the Nuclear Energy Innovation Capabilities Act (NEICA, S.97) which was signed by the President on September 28, 2018, directs the Secretary, to the maximum extent practicable, complete construction of, and approve the start of operations for the facility by no later than December 31, 2025.

During FY 2019, the Office of Nuclear Energy is focusing on pre-conceptual design development to support CD-0, *Approve Mission Need*. Following a CD-0 decision, the program will initiate conceptual design efforts for the development of a highly credible cost and schedule estimate.

Appendix H – Nuclear Innovation Clean Energy (NICE) Future Initiative



Memberships and Partnerships

Lead Countries


Canada


Japan


USA

Participant Countries


Argentina


Poland


Romania


Russia


UAE


UK

External Partners

International Energy Agency

Nuclear Energy Agency

International Framework for Nuclear Energy Collaboration

International Youth Nuclear Caucus (IYNC)

GEN IV International Forum

Third Way and Clear Path

Join Us!

- Help develop NICE Future resources and products
- Participate in NICE Future events and workshops
- Partner to deliver engagement events to communicate the vision and outcomes of the initiative
- Realize new clean energy goals in the private sector
- Share outcomes with your own networks!

Find us online:

- http://cleanenergyministerial.org/initiative-clean-energy-ministerial/nuclear-innovation-clean-energy-future-nice-future
- https://www.energy.gov/ne/nuclear-innovation-clean-energy-future
- https://www.nrcan.gc.ca/energy/20719

Contact Us

- Jordan Cox – U.S. National Renewable Energy Laboratory: jcox@nrel.gov
- Vickie Healey – U.S. National Renewable Energy Laboratory: Victoria.Healey@nrel.gov
- Giulia Bisconti – U.S. Department of Energy: giulia.bisconti@nuclear.energy.gov
- Chris Evans – Natural Resources Canada: christopherw.evans@canada.ca
- Daigo Minoshima – METI Japan: minoshima-daigo@meti.go.jp

policy makers across the clean energy sector

NICE Future Webinar Series

Upcoming Events

- Sign up to receive announcements of upcoming webinars and events and to be added to our mailing list by e-mailing Jordan Cox at jcox@nrel.gov
- Stay tuned for updates on the May 2019 Clean Energy Ministerial tenth annual meeting (CEM10) in Vancouver and related NICE Future events

Appendix I – Integrated Nuclear-Renewable Energy Systems Opportunities and Case Studies

Nuclear power plants have historically operated as a baseload generation technology, reliably providing electricity to meet the grid demand by operating at nominal plant power with capacity factors exceeding 90%. As renewable generation technologies are deployed in increasing numbers on the grid, the need for other generators to operate flexibly increases. Net demand refers to the total electricity demand less the amount met by renewable generators, which provide electricity intermittently as a function of varying weather conditions. Increased penetration of variable renewables increases the temporal variability in net demand, resulting in lower peak demand, steeper ramps, and lower minimum demand, with times of over-generation resulting in negative electricity prices on the grid. Many traditionally baseload plants are now considering or implementing flexible operation – varying the amount of electricity they supply to the grid – to accommodate this demand variability.

Anticipating increasing challenges to the electricity grid in the future, the U.S. DOE Office of Nuclear Energy (NE) established the Nuclear-Renewable Hybrid Energy Systems (N-R HES) in 2014 to begin evaluating options for the integrated or coordinated use of nuclear and renewable energy generators to meet energy demands across the electricity, industrial, and transportation sectors.[1] Implementation of novel systems integration and process design are expected to allow for expanded use of nuclear energy beyond the grid, complementing the increasing penetration of variable renewable energy generation. Close coordination of energy generation technologies has the potential to revolutionize energy services at the system level by coordinating the exchange of energy currency among the energy sectors in a manner that optimizes financial efficiency (including capital investments), maximizes thermodynamic efficiency (through best use of exergy, which is the potential to use the available energy in producing energy services), reduces environmental impacts when clean energy inputs are maximized, and provides resources for grid management. Complementary use of generation technologies is accomplished through provision of energy services and production of saleable commodities (e.g. potable water, hydrogen, etc.) produced using excess thermal and electrical energy from the nuclear system, as illustrated in Figure I-1.

Detailed dynamic analysis is necessary to optimize the N-R HES design configurations that are the most promising for near-term applications, and which may lead to the deployment of a variety of system options in the future. The overarching goal of the N-R HES modeling and simulation activity is to optimize economic performance of candidate integrated energy system options under technical performance constraints and assurance of grid resilience. Following initial analyses that showed the potential for integrated or hybrid nuclear systems, a utility advisory committee was established to better engage owners and operators of the current fleet of light water reactors and to establish realistic case studies for potential demonstration of these technologies.

[1] Bragg-Sitton, S.M., Boardman, R., Rabiti, C., Kim, J.S., McKellar, M., Sabharwall, P., and Chen, J., Nuclear-Renewable Hybrid Energy Systems 2016 Technology Development Program Plan, INL/EXT-16-38165, March 2016, available at https://www.osti.gov/scitech/biblio/1333006.

The following case studies are currently being implemented within the DOE-NE N-R HES program:

- **Case I: Nuclear-Renewable-Water Integration in Arizona**
  - Electrical integration of existing nuclear generation and desalination processes in a region with significant solar generation
  - Collaboration with Arizona Public Service (APS), operating owner of Palo Verde Generating Station, with consultation from Electric Power Research Institute (EPRI).
- **Case II: Nuclear-Industrial Process Variable Hybrid in the Midwest**
  - Retrofit of an existing LWR to support an industrial application and electricity production in a region with significant wind generation
  - Focus on bulk hydrogen generation and associated energy storage or use in off-take industries (e.g., steel making or ammonia production, fuel cell vehicles)
  - Collaboration with multiple industrial partners, led by Exelon; jointly funded by the DOE Office of Energy Efficiency and Renewable Energy (EERE) Hydrogen at Scale (H2@Scale) Program.
- **Case III: Nuclear-Chemical Plant Integration**
  - Evaluate potential to replace existing coal/natural gas thermal power sources with multiple small modular reactors
  - Analysis of operational cost and system reliability in collaboration with Eastman Chemical, which was recently awarded a GAIN voucher to support this work.

These case studies will produce sufficiently detailed technical and economic assessments to support a utility decision to proceed to a near-term demonstration of the integrated system proposed with the selected operating LWR.

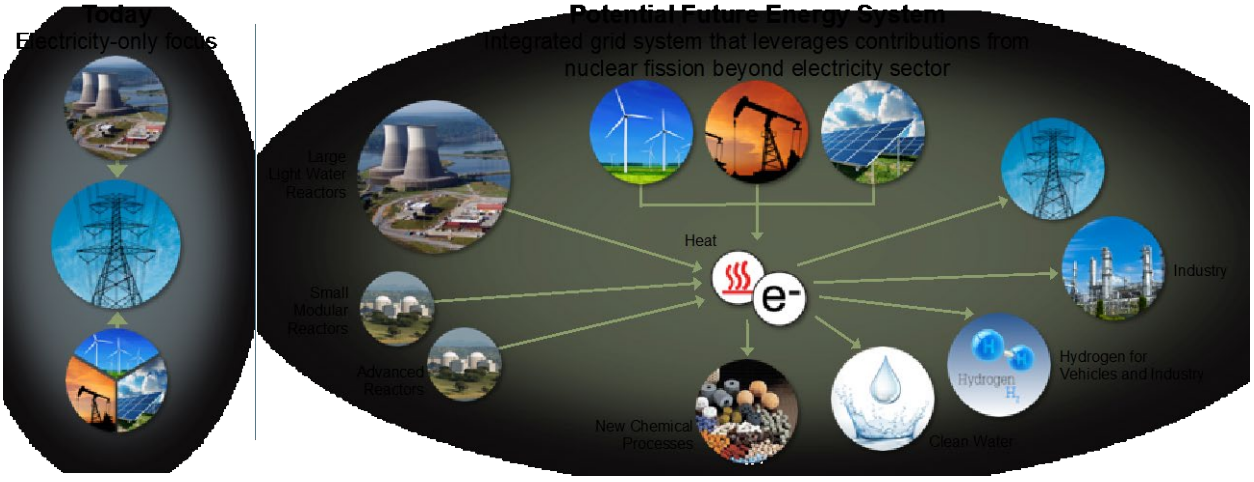


Figure I-1. Coordination of Energy Generation Sources and Demand to Maximize Flexibility and Economic Performance While Ensuring Grid Reliability and Resilience.[2]

[2] Bragg-Sitton, S., et al., *Nuclear Energy Reimagined*, presented at the 2017 DOE Big Ideas Summit, Washington, D.C., March 2017.

In addition to the proposed demonstration of integrated energy systems with an operating large-scale nuclear plant, the research team is constructing a scaled, electrically heated integrated test facility at Idaho National Laboratory (INL). The INL facility will include renewable generators, power systems, energy storage, and both thermal and electrical energy users that are physically integrated with an electrically-heated loop that emulates thermal energy input from a nuclear fission reactor. System tests will be designed to demonstrate coordinated and efficient multi-directional transient distribution of electricity and heat for power generation, storage, and industrial end uses. This test bed will provide significant insight to integrated system operation and control under both nominal and postulated accident conditions; results will be used to guide integrated system demonstration with an operating nuclear plant.

Laboratory researchers are additionally engaged with small modular reactor (SMR) developers to ascertain the potential for the use of SMRs or other advanced reactor deployment in hybrid configuration that allows for coordination with renewable energy generators to produce both electricity and heat or other saleable commodities. The Joint Use Modular Plant (JUMP) program, conducted in connection with the UAMPS/NuScale Carbon Free Power Project at INL, will provide a unique opportunity to conduct research within an operating commercial reactor environment. As announced in a recent memorandum of understanding between UAMPS, DOE and Battelle Energy Alliance (which operates INL), the first module in the UAMPS plant is planned for research, development and demonstration activities under the JUMP program. The primary research application is to demonstrate the use of single nuclear module beyond the electricity sector, either for energy storage or a coupled industrial application (e.g. hydrogen production, water desalination, etc.). The JUMP module is expected to be completed in 2026, with integrated system demonstrations then beginning in early 2027.

Nuclear energy is vital to the future economic growth of the U.S. and central to our energy security. The N-R HES program is actively bringing together nuclear technology developers and industrial users of nuclear energy to establish a new paradigm for industrial energy production and use alongside traditional electricity generation.

Appendix J – U.S. International Development Finance Corporation

FAQs ON BUILD ACT IMPLEMENTATION

Q. What will the new agency be called?

- The *U.S. International Development Finance Corporation* will go by the acronym "***USDFC***" and be known colloquially as the "DFC."

Q. Why is the U.S. government creating a new agency?

- The Administration recognizes the important role of development finance to advance our development and foreign policy goals, as was articulated in the *National Security Strategy.* Yet the U.S. government's development finance tools have not been significantly updated since OPIC's inception in 1971. The new DFC will modernize the U.S. government's capabilities to better partner with allies and provide financially-sound alternatives to state-led initiatives from countries like China.

Q. How will the DFC be different?

- ***Equity Authority:*** In addition to OPIC and DCA's current financial capabilities (loans, loan guarantees, political risk insurance, and investment funds), the DFC will have the ability to make limited equity investments. This will give the U.S. the "full suite" of financial tools, allowing the DFC to better partner with allies and partners for greater development impact.
- ***A Higher Investment Cap:*** The BUILD Act raises the total investment limitation for the DFC to *$60 billion* - more than double OPIC's *$29 billion* investment cap - along with increased oversight.
- ***Technical Assistance/Feasibility Studies:*** The DFC will have the ability to provide technical assistance and conduct feasibility studies specific to development finance projects.
- ***Increased Integration and Coordination with the State Department and USAID:*** The DFC will work side by side with State and USAID to leverage each other's tools and international presence.
- ***Focus on the low-income and lower-middle income countries:*** Prioritizes low-income and low-middle income countries, where the DFC's services will have the greatest impact.

Q: How is this different than China?

- The DFC will advance private-sector-led development, resulting in projects that adhere to high standards and are financially viable over the long haul. Contracts will be transparent, financing is sustainable, economic and social impacts are properly assessed, and projects will help the local economy in many ways.
- The DFC will help countries sidestep opaque and unsustainable debt traps being laid by Beijing throughout the developing world and help more American businesses invest in emerging markets, including many places that are of key strategic importance to the United States.

Q. Is this a replacement for grant-based foreign aid?

- No. The DFC will be a strong complement to the work of other U.S. government aid programs.

Q. What does this mean for EXIM Bank?

- The DFC will be the U.S. Government's development finance institution, and EXIM will continue to be its export credit agency.

https://www.opic.gov/build-act/faqs-build-act-implementation