

# Departmental Response:

## Assessment of the Report of the SEAB Task Force on the Future of Nuclear Power



### Introduction

In December 2015, Energy Secretary Ernest Moniz charged the Secretary of Energy Advisory Board (SEAB) to form a Task Force on the Future of Nuclear Power (Task Force). The Task Force was charged with describing “the landscape that must be crossed to go from today’s situation of reliance largely on light water reactors to a situation in the period 2030 to 2050 where one or many nuclear technologies have reached technical and commercial maturity and are deploying at a rate that has the possibility of carbon-free nuclear power generation contributing 20 percent of global electricity generation.” More specifically, the Task Force was asked to develop an illustrative schedule and to describe the potential costs, scope, and regulatory and programmatic considerations for achieving this vision. The Task Force notes in its report that it was not asked to examine whether this nuclear energy initiative is of greater priority than other initiatives or to review the current DOE nuclear energy research and development (R&D) program. It describes the DOE Office of Nuclear Energy’s R&D portfolio as supporting “the nuclear technology base for the Nation that allows private firms, national laboratories, and universities to create technology options for the future” and its own focus as being “on the downstream innovation stages of demonstration and deployment.”

In its September 2016 report, the Task Force concludes: *...there is no shortcut to reestablish a vigorous U.S. nuclear power initiative that could be a major source of carbon-free generation. To be successful, such an initiative will take time, significant public resources, restructured electricity markets, and sustained and skilled management attention.* Consistent with this finding, the Task Force recommends pursuit of this goal via a significant nuclear initiative with two major parts and offers a number of additional recommendations, suggestions, and opinions on its potential implementation. The first part of the nuclear initiative is designed to ensure that the electricity market appropriately values the carbon-free baseload generation offered by light water reactors, recommending a production payment for new nuclear plants in the absence of a national carbon-emission pricing policy. In a related recommendation, the Task Force also endorses ongoing efforts “to encourage arrangements that will preserve the U.S. fleet until the end of their useful life, subject to continued compliance with prevailing safety and environmental regulations.”

The second part of the nuclear initiative would launch an advanced nuclear reactor development and demonstration effort leading to a U.S.-based “capability to deploy new nuclear power plants at the rate of 3 to 5 GWe per year, in the 2030–2050 time frame”. The Task Force report provides what it describes as a “program template” arranged into four phases that could notionally lead to a first-of-a-kind (FOAK) commercial-scale plant operating in approximately 25 years at a cost of \$11.5 billion, using midpoint cost and schedule estimates. These costs would be shared between government and industry.

This report outlines the initiative recommended by the SEAB Task Force and its recommended implementation approach, provides the Department of Energy (DOE) assessment of those recommendations, and summarizes actions being undertaken by DOE. In presenting its recommended implementation strategy, the Task Force also identified a number of areas that should be considered further by DOE before finalizing key implementation decisions; this report discusses those and offers additional matters that DOE believes should also be considered.

## **Response to the Task Force Recommended Nuclear Initiative**

Early in its report, the Task Force identifies a list of the key challenges to market implementation of new nuclear power plants, some of which are also challenging the ability of existing plants to remain competitive. These include:

- Economic cost, value, and market risk for nuclear power;
- Safety and licensing;
- Choice of nuclear technology;
- Schedule and cost for nuclear power technology innovation;
- Nuclear waste management and public acceptability; and
- International linkages.

The remainder of the Task Force report focuses on addressing these challenges with a major new nuclear initiative. In proposing this new initiative, the Task Force differentiates it from DOE's current nuclear energy programs, highlighting the importance of its "investments in people, facilities, and R&D that create technology options for the future," and recommends against diverting resources from ongoing research and development as a source of funding for a new initiative.

The Task Force report offers a number of key observations, opinions and supporting evidence, culminating in recommendations to support the continued viability of the existing light water reactor fleet, to provide appropriate economic incentives for deployment-ready technologies and to advance at least one advanced reactor design through FOAK commercial deployment. These key recommendations are summarized here with the DOE response. Additional Task Force recommendations and DOE considerations related to the selection of a specific implementation strategy are discussed later in this response.

### ***Existing Nuclear Plants***

For existing nuclear plants, the Task Force endorses ongoing efforts among DOE, the Federal Energy Regulatory Commission, State regulatory authorities, and regional and independent system operators related to the market conditions for the existing U.S. nuclear fleet. The Task Force report summarizes the involved issues and the options being pursued to resolve them, but notes that there may not be a single solution that fits all regional market situations and stops short of recommending one specific approach applicable to all situations. Instead, it notes the importance of encouraging "arrangements that will preserve the U.S. fleet until the end of their useful life, subject to continued compliance with prevailing safety and environmental regulations. The Task Force believes this is essential if U.S. carbon goals are to be achieved."

DOE agrees with the Task Force that U.S. carbon reduction goals may not be achieved without ensuring the continued availability of the existing light water reactor fleet. To further this point, on May 19, 2016, the Energy Department convened a meeting of experts and stakeholders to discuss means of improving the economics of America's nuclear power plants. Secretary Moniz, Members of Congress, State and local government leaders, industry, stakeholders, and other experts discussed potential solutions to address the economic challenges facing a number of nuclear power plants in the United States. The summit identified potential policy options that can be pursued at Federal and State levels to address these concerns, as well as technical options that utilities can use to improve the economic competitiveness of operating nuclear power plants. A summary report, which includes many of the options identified by the Task Force and cost gap analysis, was prepared following this summit and is available at <https://gain.inl.gov>.

In addition to using its convening power, DOE's research programs are also working in a number of areas that may begin having an impact in the 2020 timeframe to address longer-term solutions to these issues. DOE is supporting R&D in a number of programs that can enable plant performance gains and reduce operating costs. Almost a year ago, DOE launched a working group of experts from industry, national laboratories, academia, and regulators to identify research, development, and demonstration opportunities that could prove economically beneficial and is currently working to incorporate recommendations into DOE's R&D programs. Furthermore, the DOE Light Water Reactor Sustainability program is working to develop the science, technologies and other solutions that can extend the life of the current fleet of nuclear power plants, while sustaining the safety and improving economics and reliability of currently operating plants.

Lastly, the first installment of the Quadrennial Energy Review (QER) included a recommendation to appropriately value electricity services and technologies, as also noted by the Task Force. DOE is acting on this in the second installment of the QER. Decisions about energy tariffs, policies, and market structures should consider a full suite of value streams, including reliability, flexibility, resilience, environmental benefits, security, and others.

### *New Nuclear Plants*

The Task Force report assesses the economic and market factors affecting nuclear power while acknowledging that there is a great deal of uncertainty in forecasting for the time frames under discussion. From this analysis, the Task Force identifies three statements as important messages supporting its economic recommendations:

- Nuclear levelized cost of electricity (LCOE) does not compete with coal, natural gas, and renewables if only private costs (the costs incurred by investors and operators in commercial markets) are considered.
- Nuclear LCOE does compete with coal and renewables when external costs (costs that are not captured in commercial markets) are considered, as well as intermittency costs for renewables, but not with natural gas at Energy Information Administration's (EIA) 2016 natural gas price projections.
- Natural gas prices are notoriously volatile, as are EIA natural gas price projections. Under EIA's 2015 natural gas price projections, nuclear LCOE would be competitive with natural gas when external costs are considered or when natural gas plants are equipped with 90 percent carbon capture and sequestration.

The Task Force describes one of the key challenges to the deployment of additional nuclear generating capacity as the failure of current policies and market designs “to recognize fully the zero-carbon, base load, nonproliferation, and other values of nuclear power generation in the United States. The Task Force believes that the success of the nuclear initiative under consideration will require reforms that resolve these market design and policy shortcomings.” In the continued absence of a national carbon-emission pricing policy, the report recommends that the Administration seek a production payment of approximately \$0.015 – \$0.027/kWe-hr for carbon-free electricity generated by new light water reactors, for a time period to be determined.

The Task Force states that its recommended production payment above is the only significant support required for deployment of currently available (i.e., “technology ready”) light water reactors, often referred to as “Generation (GEN) III+” reactors. Additional technology R&D is viewed by the Task Force as unnecessary to encourage additional deployment because this class of reactor technology is already in commercial operation. The report does note additional opportunities exist for DOE to advance the deployment of small modular reactors (SMRs), which are nearing readiness for commercial deployment and may offer additional advantages over larger GEN III+ reactors. The recommendation notes the work that DOE is already doing to support design certification, licensing and early siting of SMRs and encourages DOE to work with the Nuclear Regulatory Commission (NRC) expeditiously to resolve remaining licensing issues.

The Department agrees that a production payment may serve as a useful incentive to spur new nuclear deployment. The currently available production tax credit (PTC) of \$0.018/kWe, as well as, DOE’s Loan Guarantee Program contributed to the decisions to build the four nuclear units currently under construction. Should the in-service date of the current PTC be extended or removed, additional units could take advantage of this opportunity up to the current cap of 6,000 MW, which could also be increased. An increase in the value could also prove to be useful in incentivizing new nuclear construction.

However, the Department also believes, and the Task Forces notes, that capital costs and construction times must continue to decline. Reestablishment of diminished supply chains, as well as lessons learned from the units currently under construction will almost certainly help drive down the costs of future builds. The Department continues monitoring progress and should opportunities to provide technical or financial assistance beyond the current R&D and Loan Guarantee programs become apparent, DOE will consider appropriate actions.

DOE agrees with the Task Force’s assessment that innovative SMR technologies have the potential to offer a solution for the Nation’s clean energy future. Continued support for SMR development and deployment is expected to have a multitude of domestic benefits, including the addition of clean power choices for utilities, recapturing of a leadership role in nuclear technology development, export opportunities, and job growth as the domestic manufacturing enterprise develops. The support that DOE has provided to date on the certification and licensing projects has been effective in moving our industry partners closer to SMR deployment. However, the Department recognizes that more needs to be done to assure that we can meet our commercialization and deployment goals.

## *Advanced Nuclear Reactors*

For emerging technologies, the Task Force recommends launching an advanced nuclear reactor program now that will reduce risks and lead to U.S.-based capacity to produce and deploy advanced reactor technologies in the 2030–2050 time frame. The report states that these advanced reactors, also known as “GEN IV reactors” have the potential to offer lower overnight capital costs, higher efficiency and improvements in safety and fuel utilization, making consideration of an advanced nuclear reactor initiative both timely and warranted.

The Task Force report provides what it describes as a “program template” arranged into four phases separated by clear go/no-go decision milestones. This template could notionally lead to a FOAK commercial-scale plant operating in approximately 25 years at a cost of \$11.5 billion, using midpoint cost and schedule estimates. The Task Force notes a number of additional considerations that could affect this program template, and encouraged flexibility in its application. Specifically, the report describes the purpose of the template as “to give an impression of the scale in terms of time and money needed to successfully accomplish the deployment of a new nuclear reactor technology” and describes the Task Force intent as “proposing a program initiative rather than prescribing a rigid path.”

The first phase of the program would undertake the additional technology development, engineering, and systems analysis necessary to compare the characteristics of potential advanced reactor designs to those of existing light water reactor systems. This phase, estimated by the Task Force to require approximately five years, would culminate in a down-selection and decision to proceed with one or more advanced nuclear reactor technologies. The second phase involves subsystem development and validation, front-end engineering design, and NRC demonstration plant licensing. The third phase would construct and operate a demonstration plant while simultaneously pursuing detailed design for a FOAK commercial plant, and the final phase would construct and operate the FOAK commercial-scale plant. The program’s final milestone would be a commitment from private investors, banks, utilities, and owner/operators to a first wave of commercial construction. The Task Force states that the specific objectives of its proposed four-phase program do not require the construction of a test reactor, relying instead on existing and planned international capabilities. Its report notes, however, that a test reactor “may be desirable for the long-term health of the U.S. nuclear technology base” and recommends that DOE consider the benefits of international participation if a test reactor project proceeds.

The Task Force analysis has identified a number of the significant barriers that continue to challenge the entry of advanced reactor concepts into the marketplace and recommended an initiative on the scale necessary to overcome these. DOE agrees that a clearly defined path to deployment with specific milestones and an innovative, market-informed strategy and an appropriate Federal government role are critical elements to the successful deployment of advanced reactors at the envisioned pace and scale. The Task Force also encourages DOE to broaden its consideration of technologies to ensure that innovative concepts have an appropriate opportunity to compete. DOE agrees with the Task Force that technological innovation is a necessary element in the U.S. ability to meet its clean power goals that should be encouraged as part of any nuclear initiative. The challenge to incorporating such an element in a schedule-driven initiative is to quickly identify those concepts that can realistically achieve market readiness in the envisioned time frame and focus on the most commercially viable options among them. The different pathways of these technologies could require modifications to the

recommended phasing structure and timeline and could affect the irradiation testing and demonstration reactor capabilities that may be needed; however, technology readiness is only one of many factors DOE would consider in such a decision.

Prior to issuance of the Task Force final report, the DOE Office of Nuclear Energy had also charged the Nuclear Energy Advisory Committee (NEAC), an independent advisory body comprising experts from universities, national laboratories and industry, with separately examining the need for a U.S. test reactor capability in support of advanced reactor deployment and light water reactor R&D. A report of this study's findings is expected to be released in the first quarter of 2017. DOE will consider this independent input alongside that of the Task Force and other available information as it assesses the role of test reactor capabilities and formulates a strategy for encouraging advanced reactor deployment. The Task Force report acknowledges this ongoing effort to assess U.S. test reactor needs, noting that such a reactor may offer benefits to the "long-term health of the U.S. nuclear technology base." The Task Force also highlights the cost and time associated with such a project and recommends that DOE consider possible international participation in any such project that proceeds. Such international considerations are being examined as part of the above-mentioned NEAC study.

DOE's draft *Vision and Strategy for the Development and Deployment of Advanced Reactors* provides a schedule that is similar to that proposed by the Task Force. A demonstration/test reactor is operational between 2025 and 2030, or in approximately 12 years. DOE's vision for completing the first commercial unit by 2035 is slightly earlier than the earliest date provided by the Task Force, 22 years from now.

DOE agrees that the overall four-phase approach to implementation recommended by the Task Force is a viable approach leading to the deployment of advanced reactors, but the proposed phases, schedule, and specific cost sharing arrangements may need tailoring to reflect a spectrum of technical maturity levels of different reactor technologies. Such tailoring would remain consistent with a key principle included in the Task Force's recommended approach, in that the Federal government would provide greater levels of cost share during research, design and licensing phases and less cost share during construction phases. A great deal of work remains to understand the characteristics and technology maturation needs of the various advanced reactor technologies relative to each other and to light water reactors in sufficient detail to support decision-making and detailed deployment planning. DOE believes that it can begin working toward the preliminary goals of the Task Force recommended initiative in parallel with continued discussion about the later phases of an advanced reactor deployment program and its governance structure in order to begin the initial R&D phase.

One mechanism under which DOE is pursuing the type of R&D that the Task Force recommended as Phase I of its advanced reactor deployment program is the Gateway for Accelerated Innovation in Nuclear (GAIN) initiative. Launched in November 2015, the goal of the public-private partnership envisioned under GAIN is to provide the nuclear community with access to the technical, regulatory, and financial support necessary to move innovative nuclear energy technologies toward commercialization while ensuring the continued safe, reliable, and economic operation of the existing nuclear fleet. The GAIN initiative has announced initial awards to eight small businesses via the Nuclear Energy Voucher pilot program, granting them access to the extensive nuclear research capabilities of DOE. Through GAIN, DOE is engaging nuclear innovators to determine R&D needs and deployment plans. From these interactions,



DOE has recognized that many innovators are working on commercial deployment dates that are more aggressive than those proposed by the Task Force and outlined in DOE's vision. As the GAIN initiative continues to grow, it will serve as an immediately available mechanism to partner industry-led research teams with cutting edge DOE capabilities and expertise to accelerate advanced reactor concepts toward market readiness.

## **Response to the Task Force Recommended Implementation Strategies**

In addition to recommending the two-part nuclear initiative discussed above, the Task Force report devotes significant attention to issues that have posed challenges in the past and recommends means of addressing them as part of a successful implementation approach for an advanced reactor deployment program. These recommendations describe the program's phased structure and financing, its management approach and governance structure, licensing challenges and the role of international collaboration.

### *Financing the Phased Approach*

The Task Force recommends dividing the recommended advanced reactor program into four phases and adjusting the cost-sharing approach between industry and the government to mirror the evolution of risk through those phases and to allow the government to retain control over intellectual property during the early phases. The Task Force acknowledges that its cost and schedule estimates are highly uncertain, but anticipates that the effort will require on the order of \$11.5B over 25 years, using midpoint estimates. The Task Force report describes its intent in providing estimates as conveying the overall scale of the needed effort and setting a general direction. The Task Force encourages flexibility at this time rather than a rigidly structured set of phases because the needs associated with specific concepts will likely evolve during or after the down-selection process, and because it may be appropriate to select more than one concept.

The first phase of the effort continues the research and development of advanced reactor designs to narrow uncertainties, but with a focus on moving them toward a down-selection milestone, estimated to require approximately five years and \$2 billion. The second phase, described by the Task Force as the reactor demonstration preparation phase, involves the design, licensing, and subsystem development for a demonstration reactor. It concludes at a decision point to proceed with the construction of the demonstration reactor and is estimated to require approximately \$3 billion over seven years. The third phase constructs and operates the demonstration reactor and prepares for construction of a FOAK commercial plant. This phase includes preparing a detailed design, and performing in-depth analysis of commercial viability, while the owner/operator proceeds to secure the licensing approvals, electricity off-take agreements, and financing needed to support the FOAK plant. The third phase culminates in a decision to proceed with construction of the FOAK plant and is estimated at \$3.5 billion over seven years. The final stage involves constructing and operating the FOAK plant, and ends with a commitment to commercial operation. Its estimated cost is \$3 billion over six years.

The recommended cost-sharing structure includes full government funding of the initial phase, industry and government cost-sharing of the second and third phases, and full industry funding of the final phase. There are two primary reasons for this. The first is the evolution of risk over the program. Industry is more willing to assume costs as the technology matures and its

commercial risks and potential benefits are clearer. The other involves realizing key government's objectives in funding the early stages of technology R&D, which include ensuring access to the results and benefits of the public investment and maintaining a broad industry base. These objectives are best realized when the government controls the intellectual property resulting from its investments so that it can be shared broadly with industry. In contrast, by the later phases all of the viable available concepts have been provided with opportunities to mature, and the government will no longer be developing broadly applicable technologies. As one or more designs advance toward commercial profitability, the industry sponsor(s) will bear an increasing share of the cost and will retain the intellectual property developed.

DOE appreciates the Task Force perspectives on the overall scope of the effort and the challenges associated with funding, particularly during the early phases. Any related work that DOE initiates in the near-term would use a cost-sharing model consistent with the Energy Policy Act of 2005. If the advanced reactor deployment program recommended by the Task Force is initiated, further consideration will be given to appropriate levels of cost share as part of the discussion among key stakeholders to establish the program approach.

### *Management Approach and Governance*

The Task Force identifies six characteristics that it describes as required in a governance structure for the recommended advanced reactor program:

1. a stable financial plan free from the annual congressional budget cycle;
2. authority to deploy a variety of contractual support mechanisms, appropriate to stage of development of the selected reactor projects;
3. freedom from Federal acquisition regulations so that program development and deployment can proceed under commercial practice;
4. access to adequate technical and financial expertise required for due diligence before program decisions are made, in particular the DOE national laboratories;
5. authority to terminate a project that does not meet milestones or is judged not to have the prospect to achieve economic costs of power; and
6. freedom to use commercial employment practices in the hiring and removal of project staff.

It also identifies key government roles in the program:

- Maintaining a nuclear technology base that creates future capability and human capital;
- Establishing a stable market and regulatory structure enforced by State and Federal authorities, which is needed by private investors;
- Assuring safety and security in the construction and operation of nuclear power reactors and associated fuel-cycle facilities both domestically and internationally;
- Managing the international linkage of nuclear power, especially nonproliferation, safety, and waste management activities; and
- Addressing the management of nuclear waste.



To meet its identified requirements in the context of an appropriate government role, the Task Force considered three approaches to governance for the initiative: 1) Laissez-faire policy initiatives are adopted (rate structure, safety and security, perhaps a CO2 emission charge) that enable market-driven investment; 2) an initiative planned and led by DOE; and 3) a quasi-public corporation. From among these options, the Task Force recommends that a quasi-public corporation be established with the authority and responsibility to undertake all four phases of the advanced nuclear initiative. The report states that this is the most likely way for Congress to grant special operating exceptions supported by tax payer money, and that its practices would align more to a private sector entity than a government agency unit, offering the greatest chance of success for an initiative to demonstrate the risk reduction required for private investment. The board of directors for the recommended corporation would be independent, nominated by the President and confirmed by the Senate. The report recommends funding via a one-time congressional appropriation and authorizing legislation that would enable it to function in a “largely commercial manner, free of the Federal acquisition and personnel restrictions and the annual budget/appropriation cycle.” The responsibility for adjusting the market structure and licensing process would remain with the executive branch agencies.

The Department agrees that innovation and market focus are important considerations in designing the governance structure for the initiative. The Department is intrigued by the Task Force recommendation regarding the formation of a quasi-public corporation and it is an option that will be explored. The concept is similar to that recommended by the Blue Ribbon Commission for the management of nuclear waste transportation, storage, and disposal. In the case of the nuclear waste management, the rationale for a new organization was grounded in the fact that a long history of contentious Federal-State-community issues needs to be resolved and the desired outcome, a small number of repositories and spent fuel storage sites, is clear. For the advanced reactor initiative, the rationale needs further discussion, especially for the early R&D phase. Given the timeliness of the advanced reactor initiative, if funding is available in FY 2018, the Department believes that the early phases of the initiative should be launched as the organizational structure is resolved.

### *Licensing Considerations*

The Task Force report devotes considerable attention to a discussion of the U.S. reactor licensing process, comparing and contrasting it to its international counterparts and emphasizing the importance of retaining the “gold standard” of safety that the U.S. system offers. In the context of its recommended initiative, the report cites features of the licensing process that may pose challenges to the introduction of new designs, specifically to those advanced concepts for which the approach to safety in design is very different from that of light water reactors. The Task Force recommends legislative action to adjust the means by which the NRC is funded, on the basis that its current reimbursement requirements discourage early interaction between reactor designers and regulators.

More specific to implementation of the advanced reactor initiative, the Task Force recommends involvement of the NRC throughout the four-phase deployment initiative to ensure that regulatory and licensing considerations are understood and factored into the planning as early as possible. For DOE specifically, the Task Force recommends expansion of its efforts to assist in the licensing of advanced designs and in the development of codes and data to facilitate the

analysis of safety decisions. It also recommends that DOE ensure private industry and university access to relevant capabilities from across the DOE complex.

The NRC has provided comments on matters in the report related to its own activities and processes. With respect to the Task Force comments on collaboration between DOE and the NRC, DOE agrees that this is required for successful advanced reactor deployment, and intends to continue engaging with the NRC in its technology R&D, testing and code development efforts.

### *International Considerations*

The Task Force recognizes the international nature of current advanced reactor R&D and identifies several areas of potential intersection with its proposed nuclear initiative. In the policy area, the Task Force recommends that DOE and the NRC continue international efforts to ensure that U.S. technology and safety processes serve as benchmarks for others. It also recommends that the United States, in cooperation with the International Atomic Energy Agency, lead efforts to ensure the security of nuclear facilities in the U.S. and internationally.

Specific to the implementation of the advanced reactor program, the Task Force recommends that any program to build a demonstration plant should be open to foreign participation, particularly from close allies. The Task Force believes that this could include technical contribution, cost sharing, and the opportunity to shape future commercial deployments around the world. However, the Task Force advises against entering into a multilateral governance structure because of its added complexity.

DOE agrees with the Task Force that international collaborations, such as through the Generation IV International Forum (GIF), the IAEA and the Organization for Economic Cooperation and Development's Nuclear Energy Agency are essential to the future deployment of advanced nuclear reactor technology. These collaborations will enable the United States to leverage its investments to support research needed by reactor designers and to provide the needed technical basis to establish a regulatory framework that will be globally accepted.