Shultz-Stephenson Task Force on Energy Policy

Reinventing Nuclear Power Essay Series

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The Case for Government Investment in Small Modular Nuclear Reactors

William J. Madia

The justification for initiating US government investment in nuclear small modular reactor (SMR) technology is derived from the environmental, security, and economic policy goals associated with the successful deployment of this disruptive innovation in clean energy. These policy goals include:

- Reducing greenhouse gas emissions by deploying carbon-free energy generation to replace the several hundred coal-fired power plants that are set to retire by the mid-2020s
- Supporting new high-technology manufacturing jobs
- Offsetting the increasing geopolitical influence that Russia and China may derive from their aggressive commercial nuclear power strategies
- Reinforcing and strengthening the industrial manufacturing base that supports the US Navy's nuclear propulsion requirements as well as the broader commercial nuclear power supply chain

It is for these reasons that Energy Secretary Ernest Moniz recently highlighted acceleration of the "timelines for commercialization of small modular nuclear reactors through cost-shared agreements with industry partners" as a key objective of the Obama administration's "all of the above" energy strategy.[1]

1. US Department of Energy, "Strategic Plan, 2014–2018," March 2014.

In order to achieve these policy goals, the US government must develop and execute a set of partnering strategies with the key stakeholders (vendors, utilities, and end-use energy customers) critical to the successful commercialization of SMR technology.

Generally, the path to SMR commercialization follows three steps:

1. SMR vendors develop commercially viable *reactor designs* to the point where they can be subsequently reviewed and certified safe by the US Nuclear Regulatory Commission (NRC).
2. Vendors and electric utilities or other power suppliers complete standard SMR *plant designs*, develop preliminary cost and schedule forecasts, and make ready the associated equipment supply chain. Then utilities or suppliers commence site licensing, adapt the standard plant design to the site, undertake limited site development, and begin long-lead procurements.
3. Electric utilities develop *commercially justifiable business cases* for capital investment in SMRs based on market demand, the projected costs of SMR deployment, and the forecasted long-term cost of alternatives.

Once all of these steps have been successfully completed, SMR vendors and engineering, procurement, and construction (EPC) firms can contract with utilities to manufacture and deploy SMRs, thereby earning an economic return on their research, development, demonstration, and testing investments. Similarly, only after SMRs have been constructed and utilities have received operating licenses from the NRC can utilities sell power generated by the SMRs to end-use customers or electricity retailers, thereby making economic returns on their capital investments.

Each of these key stakeholders faces different challenges and risks along this pathway and would require different types of support and strategies for SMRs to be successfully commercialized. All successfully commercialized nuclear energy technologies, especially those from Japan, France, Russia, and China, have relied on substantial government investment to overcome these challenges and risks. Without significant and direct US government action to support a nascent domestic SMR industry, US policy goals that rely on SMR commercialization will be at risk.

Recognizing these issues, the US government should focus on stakeholder-specific programs if it wishes to successfully promote and encourage the industry to move forward with the commercialization of SMRs. In particular, the licensing and regulatory risks are perceived by investors as having the largest and most problematic uncertainty.

The four US-based SMR vendors (Holtec, NuScale, mPower, and Westinghouse) have been pursuing light water-cooled and moderated SMR design, development, and testing programs that are intended to culminate in NRC review and subsequent certification that their SMR designs are safe. However, NuScale now seems to be the only active party based on the level of engagement with NRC and customers. Westinghouse and mPower have made public statements indicating their programs are being slowed or possibly even closed. Obtaining US NRC design certification is the primary and preferred product development milestone needed by each of these vendors to begin commercialization of its SMR in this country. A design certification received elsewhere globally is considered far less valuable. With an NRC-certified SMR design in hand, vendors can approach utilities to negotiate construction contracts, representing that their designs can be licensed for operation by the NRC. In addition, NRC design certification provides assurance to SMR vendors, prospective utility owners, and equipment suppliers that the SMR technologies merit further investment in design completion and preparation of the supply chains to begin manufacturing.

However, before contracting for deployment of SMRs, all utilities must be able to justify the associated capital investment in new generating assets. These justifications depend primarily on the projected costs of building SMRs and the long-term price of power alternatives, both of which must take into account possible changes in energy markets and policies as well as a variety of business and regulatory risks and considerations. Given this significant uncertainty, the US Department of Energy (DOE) and other agencies of the US government such as the Department of Defense are uniquely positioned to lead the early market adoption of SMRs in this country. The DOE has a clear charter for demonstrating clean energy technologies by investing in programs that "buy down" the technical and licensing risks associated with development and deployment of new commercial energy technologies. Furthermore, DOE operates many energy-intensive facilities, such as particle accelerators and high-performance computing centers, which are ideal users of the clean and reliable power produced by SMRs. Also, many DOE sites struggle to meet President Obama's 2015 Executive Order 13693, which requires federal agencies to reduce greenhouse gas emissions, among other things.[2] This executive order redefines "alternative energy" sources to include small modular nuclear reactors. This single action might allow DOE sites to now view deployment of SMRs to power their facilities as the best means to achieve this commitment.

Vendors

For the US-based SMR vendors, the investment needed to fully develop, test, and certify their designs by the NRC is at least $1 billion each. Due to the magnitude of this investment, together with the long time horizon for vendors to achieve a return on investment (more than ten years from initial engineering to significant revenues from utility deployment contracts), fully financing the development of SMRs by private industry, including sources like financial institutions and publicly traded company shareholders, is not realistic. To overcome this financial barrier, DOE would reasonably need to contribute at least 50 percent of all development and NRC licensing costs for each vendor to certify its SMR design. DOE's current SMR Licensing Technical Support program is a good start. But if it does not go further, the United States could reasonably be expected to miss out on this market. Because the four US-based SMR designs are in widely varying states of maturity, ranging from early

2. The White House, "Planning for Federal Sustainability in the Next Decade," news release, March 19, 2015, https://www.whitehouse.gov/the-press-office/2015/03/19/executive-order-planning-federal-sustainability-next-decade.

technology concepts to reasonably well-developed preliminary designs, and because funding limitations will not allow DOE to support the development of all four designs, a "down select" or consolidation among these SMR designs is necessary. But since NuScale appears to be the only remaining viable program, finding the necessary funding might be achievable.

Utilities

For utilities, becoming an early adopter of SMRs means co-funding at least some portion of the overall power plant design completion with the vendor, a process that requires additional funding of approximately $500 million to $800 million. Of course, this estimate is highly dependent on design maturity at the start and the desired design completeness expected for licensing. This "first of a kind" (FOAK) engineering has historically been a significant barrier for adoption of new nuclear technology, since it places the technical risks and economic burden on the early movers. One potential strategy here is to encourage a consortium of utilities to collectively share FOAK engineering costs so that the burden on each is reduced. If several utilities were to receive funding support from SMR vendors and DOE, the share of FOAK engineering cost for each utility would be reasonable. And since the SMR design philosophy is based on identical, factory-manufactured reactors, a consortium approach for design completion and early licensing work should be doable.

Business Case

The actual "overnight cost" for an SMR (expressed in dollars per installed kilowatt to manufacture and construct SMRs, excluding financing costs) will remain uncertain until final designs are completed and the lead plants are deployed and in commercial operation. Estimates for SMR overnight costs currently range between $5,000 and $7,000 per kilowatt of capacity.[3] Given this uncertainty—together with current energy market distortions to the true cost of alternative generation technologies caused by such things as subsidies for renewables and the absence of explicit accounting of carbon impact from fossil fuels—the cost of electricity from SMRs is estimated to be noncompetitive with respect to other energy sources over the near-term planning horizon. However, discussions with utilities indicate that other factors such as fuel type diversity and gas price volatility are mitigating factors. Estimating risks in this highly dynamic environment makes capital investment decisions difficult.

As a result, early-adopter utilities have a strong need for long-term power purchase agreements (PPAs)—on the order of twenty to thirty years—at prices that compensate for their investment in early SMR deployment. Currently, DOE has the authority to enter into ten-year PPAs while the Department of Defense has thirty-year authority. Such financial vehicles would give utilities assurance of revenues for electricity that is generated over time.

Therefore, in order to jump-start SMR commercialization in the United States, the federal government should become this assured consumer of electricity for early-adopter utilities. By using some of its many facilities that require clean, reliable power for their scientific, technological, and national security missions, the government can quickly create a viable market for the commercialization of SMRs. By having the US government support SMR technology development and act as first mover, commercialization risks will be dramatically reduced and the economics of SMRs can be proven, thus enabling a robust private-sector domestic and international market for SMRs to be created.

A long-term government PPA approach is consistent with the position proposed for energy demonstration projects in the report entitled, "A Business Plan for America's Energy Future," published by the

3. Ahmed Abdulla, Inês Lima Azevedo, and M. Granger Morgan, "Expert assessments of the cost of light water small modular reactors," *Proceedings of the National Academy of Sciences* 110, no. 24 (June 11, 2013): 9686–9691.

American Energy Innovation Council in June 2010, in which the authors conclude:

> *The private sector has underinvested in energy innovation, and it cannot achieve these goals alone. . . . National security, national economic strength, and the environment are not primary drivers for private sector investments, but they are critical for the health of our country. They merit a public commitment. Second, large-scale deployment of many new energy technologies requires massive capital expenditures that are too risky for private investors. A new generation of microwave technology might cost $10 million to develop and can be built on existing assembly lines. That risk-reward calculus makes business sense. In contrast, a new electric power source can cost several billion dollars to develop, yet still will carry risk of technology failure or regulatory changes. And the product, electricity, is sold into a generic market that does not differentiate between clean and dirty sources. So that investment does not make sense for most companies.*

Next Steps

In summary, each stakeholder and each step in the commercialization process requires its own tailored approach based on the market and financial drivers and risk presented. This problem is not amenable to simple "one size fits all" solutions. Given this, the proposed next step to SMR commercialization should be the joint development of a stakeholder framework, including the following:

1. The US nuclear industry should convene a meeting of the key stakeholders in Congress, the White House and executive branch, and vendors and utilities to better understand their support for and commitment to SMR commercialization.
2. Based on stakeholder input, the industry should analyze the policy options available to the administration for moving forward (or not) with an SMR initiative.

3. The industry should then prepare an SMR commercialization roadmap that identifies the respective roles, contributions, and strategies of all key stakeholders.
4. Finally, interested parties should prepare an integrated programmatic budget (estimated to be between $2 billion and $4 billion) for this initiative for consideration by the administration and other stakeholders. A public-private partnership approach might be the best vehicle to implement such a program.

As I and my coauthors wrote in our essay, "Small Modular Reactors: A Call For Action," the US SMR effort is at a critical juncture:

> *SMRs offer a new approach to a familiar energy technology, one with significant environmental, energy security, and international strategic advantages. Despite industry support and a successful start to government licensing programs, a number of interrelated economic challenges remain. Widespread deployment of US-built SMRs to meet the anticipated domestic and global marketplace demand of the mid-2020s is therefore in jeopardy unless decisive action is taken now. A more proactive national strategy, starting with an integrated government and industry roadmap for SMR deployment, could make a difference and attract the necessary investments.* [4]

The step-by-step approach outlined here is one answer to that call. We hope it can lead to action.

4. William J Madia, Regis Matzie, and Gary Vine, "Small Modular Reactors: A Call For Action," *Hoover Institution Press,* July 2015, http://www.hoover.org/reinventing-nuclear-power.

About the Author

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SHULTZ-STEPHENSON TASK FORCE ON

Energy Policy

The Hoover Institution's Shultz-Stephenson Task Force on Energy Policy addresses energy policy in the United States and its effects on our domestic and international political priorities, particularly our national security.

As a result of volatile and rising energy prices and increasing global concern about climate change, two related and compelling issues—threats to national security and adverse effects of energy usage on global climate—have emerged as key adjuncts to America's energy policy; the task force will explore these subjects in detail. The task force's goals are to gather comprehensive information on current scientific and technological developments, survey the contingent policy actions, and offer a range of prescriptive policies to address our varied energy challenges. The task force will focus on public policy at all levels, from individual to global. It will then recommend policy initiatives, large and small, that can be undertaken to the advantage of both private enterprises and governments acting individually and in concert.

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