May 29, 2019

To: Advanced Research Projects Agency – Energy (ARPA-E-RFI@hq.doe.gov)

Re: Pre-pilot and pilot R&D projects to scale, mature, and advance ARPA-E funded technologies (Information Technology and Innovation Foundation response to ARPA-E RFI DE-FOA-0002120)

MAIN POINTS

1. ITIF agrees with the RFI's premise that scale-up and U.S. manufacturing of innovations made by ARPA-E award recipients is an important challenge that ARPA-E, along with other components of DOE and other federal agencies, particularly the Department of Defense, should seek to address.
2. ARPA-E should invest in scale-up, pre-pilot, or pilot projects that have the potential to provide stronger performance signals to customers and profit signals to investors than its traditional applied research projects provide.
3. The effort should be focused particularly on low-carbon energy hardware technologies that require a long time and large expenditure to commercialize and that must break into commodity markets or face competition supported by mercantilist policies of other countries.
4. ARPA-E should take a flexible approach to cost-sharing for scale-up, pre-pilot, or pilot projects, including in-kind contributions.
5. ARPA-E should encourage knowledge-sharing from scale-up, pre-pilot, or pilot projects.
6. Proposals for ARPA-E scale-up, pre-pilot, and pilot projects should be encouraged to include different and larger teams than ARPA-E applied research projects.
7. ARPA-E should require substantial US manufacturing of technologies that derive from scale-up, pre-pilot, and pilot projects.

1. ITIF agrees with the RFI's premise that scale-up and U.S. manufacturing of innovations made by ARPA-E award recipients is an important challenge that ARPA-E, along with other components of DOE and other federal agencies, particularly the Department of Defense, should seek to address.

ARPA-E fills an important gap in U.S. energy innovation. It was designed to overcome the conservative bias and focus on academic publication that limits the impact of traditional investigator-initiated projects selected through peer-review. It seeks to replicate DARPA's capability by helping energy researchers get "connected" to real-world challenges, to use William B. Bonvillian's term.[1] As the RFI notes, this connecting function is built into ARPA-E's authorizing statute.

ARPA-E's established support for proof of concept and validation projects allows ideas that might otherwise have been orphaned to move a large step closer to commercialization. However, for many energy technologies, the transition from idea to mass adoption in the market involves many further steps. Barriers may include the

[1] William B. Bonvillian, "The Connected Science Model for Innovation—The DARPA Role," in National Academies, *21st Century Innovation Systems for Japan and the United States: Lessons from a Decade of Change: Report of a Symposium* (Washington: National Academies Press, 2009).

complexity of the innovation itself, the difficulty of integrating the innovation into the existing energy system, societal and institutional risks, and conservatism and unfamiliarity among potential adopters.

An organized federal effort to further bridge the gap is long overdue. ARPA-E, which has deep knowledge about the technologies it has funded and the barriers they face, is well-positioned to extend its role further toward the market by funding scale-up, pre-pilot, or pilot projects. DOE's applied energy offices, the Department of Defense (DOD), and other federal agencies may also provide support for such projects and additional commercialization activities. For instance, a recent ITIF report found that "DOD is a natural partner for ARPA-E and the other DOE programs that support innovation in stationary storage."[2]

2. ARPA-E should invest in scale-up, pre-pilot, or pilot projects that have the potential provide stronger performance signals to customers and profit signals to investors than its traditional applied research projects provide.

ITIF and other researchers have shown that ARPA-E awards raise the odds of follow-on funding for teams and firms. In ITIF's study, ARPA-E funding was associated with a five-fold increase in the odds of being in the top 10 percent of the fundraising distribution of all similar firms. These results are statistically robust and unlikely to be the result of selection bias. ARPA-E funding signals the quality of the awarded firms' technologies to potential investors. With reduced uncertainty, investors can more suitably fit these companies into their portfolios.[3]

Despite ARPA-E's success, energy innovation is falling far short of what the United States needs to achieve national goals, including economic prosperity and environmental sustainability. One indicator is that the decline in U.S. greenhouse gas emissions has slowed in recent years, and projections suggest that they may plateau in the future. Extending ARPA-E's signaling function to the scale-up, pre-pilot, or pilot stages may help address this shortfall.

A key barrier to commercialization of energy innovation is that it is very difficult to anticipate how new energy systems will perform when they scale-up. Potential innovators must shoulder the cost and risk of building and operating larger projects, which may take several years and substantial sums of capital, and then see free riders benefit from these investments. ARPA-E funding would help reduce this risk.

3. The effort should be focused particularly on low-carbon energy hardware technologies that require a long time and large expenditure to commercialize and that must break into commodity markets or face competition from mercantilist competitors.

The RFI asks for criteria for selecting technologies to target for scale-up, pre-pilot, or pilot projects. One key set of criteria should build on ARPA-E's established role as a gap-filler. The U.S. energy innovation finance system has a significant gap for hardware technologies that require a long time and large expenditure to commercialize and that must break into commodity markets. Venture capitalists typically seek higher rewards than most technologies of this type can provide, and on a quicker timetable. A 2016 MIT study concluded that venture capital is "the wrong model for clean energy innovation."[4]

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[2] Dorothy Robyn and Jeffrey Marqusee, "The Clean Energy Dividend: Military Investment in Energy Technology and What It Means for Civilian Energy Innovation," Information Technology and Innovation Foundation, March 5, 2019, https://itif.org/publications/2019/03/05/clean-energy-dividend-military-investment-energy-technology-and-what-it

[3] David M. Hart and Michael Kearney, "ARPA-E: Versatile Catalyst for U.S. Energy Innovation," Information Technology and Innovation Foundation, November 2017, https://itif.org/publications/2017/11/15/arpa-e-versatile-catalyst-us-energy-innovation.

[4] Benjamin Gaddy, Varun Sivaram, and Francis O'Sullivan, "Venture Capital and Cleantech: The Wrong Model for Clean Energy Innovation" (working paper MITEI-WP-2016-06, MIT Energy Initiative, Cambridge, MA, July 2016), https://energy.mit.edu/wp-content/uploads/2016/07/MITEI-WP-2016-06.pdf

Some large firms, such as aircraft, semiconductor, and pharmaceutical makers, have the resources and patience to undertake projects that are very expensive and very risky. But they are in competitive, innovation-based industries where the failure to innovate often means the death of the company. The energy industry is not like that. Not innovating in the energy industry poses little risk to firms, in large part because energy is a commodity. Making the same product over time, with perhaps incremental improvements, is usually the optimal business strategy, but alas is deeply suboptimal from a societal perspective. Moreover, the rewards that accrue to energy innovators may be limited by regulators. This risk/reward ratio contributes to a culture of technological conservatism in much of the energy industry.

A final important criterion to include is the threat of "innovation mercantilism."[5] Innovation mercantilism refers to a set of policies that distort markets and undermine the conditions for innovation globally. Its traditional policy tools include forced technology transfer technology, discriminatory tariffs and massive production and export subsidies. However, acquisition and indigenization of foreign technology has emerged as a new tool of innovation mercantilism. Promising energy technologies that are orphaned by the U.S. energy innovation system, often because of foreign mercantilist practices, are targets of such activity. ARPA-E should take this threat into account as it selects technologies to support.

4. ARPA-E should take a flexible approach to cost-sharing for scale-up, pre-pilot, or pilot projects, including in-kind contributions.

ITIF endorses the principle included in the RFI that ARPA-E scale-up, pre-pilot, or pilot projects should be public-private innovation collaborations. Although the operational and reputational benefits of involvement in such projects do not generally justify private participants bearing their full costs and risks, these benefits are not negligible either. Participation may provide significant first-mover advantages in the ensuing commercial-market competition.

However, the proposed 50 percent or more cost share may be too high. A recent study of 511 demonstration projects, which are closer to the market than the projects discussed in the RFI, found that almost all of those for which data could be found involved a financial contribution from the public sector. The median public share of funding was 64 percent. Cost-sharing for this new class of projects should be flexible enough to accommodate varying risk profiles.[6]

5. ARPA-E should encourage some knowledge-sharing from scale-up, pre-pilot, or pilot projects.

Scale-up, pre-pilot, and pilot projects straddle the border between the public goods realm of scientific knowledge, in which information is widely disseminated so that it can be built upon by the scientific community, and the private goods realm of proprietary information, in which the firm that creates it limits access in order to reap a return on the investment required to create it. ARPA-E should develop mechanisms to ensure its awardees for such projects produce both public and proprietary information.

Keeping data from these projects entirely proprietary would weaken their potential to signal their technical promise of innovations being developed to the marketplace, a key purpose of ARPA-E funding. In addition, knowledge-sharing allows project failures to be diagnosed and learned from, potentially setting the stage for follow-on successes. On the other hand, it is also true that openness can reduce the private benefits of investment. But private firms providing project cost-share get some benefit from hands-on engineering knowledge as well as relationships and goodwill.

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[5] Stephen J. Ezell and Robert D. Atkinson, "The Good, the Bad, and the Ugly (and the Self-Destructive) of Innovation Policy," Information Technology and Innovation Foundation, October 2010.

[6] Gregory F. Nemet, Martina Kraus, and Vera Zipperer, "The Valley of Death, the Technology Pork Barrel, and Public Support for Large Demonstration Projects," *Energy Policy* 119: 154-167 (2018).

6. Proposals for ARPA-E scale-up, pre-pilot, and pilot projects should be encouraged to include different and larger teams than ARPA-E applied research projects.

The RFI notes that teams for ARPA-E scale-up, pre-pilot, and pilot projects may involve organizations with different capabilities than typical ARPA-E projects. That is appropriate. Project management will be more challenging for the new types of projects, involving skill sets that small firms and universities that have won most ARPA-E awards in the past may not have. More experienced technology companies with project management capabilities would be appropriate partners to add.

Such projects may also benefit from engaging additional segments of the value chain that would need to be involved in fully commercial versions of the technology. As a 2016 study put it, projects may be "purposefully used to create alliances among actors along future value chains that have the capacity to develop new technology."[7] These alliances are particularly important for technologies intended to solve systems-integration challenges that require learning by doing. Unless the same kinds of organizations are involved in the scale-up that will be involved in commercial operation, such learning may be lost.

7. ARPA-E should require substantial U.S. manufacturing of technologies that derive from scale-up, pre-pilot, and pilot projects.

The transition to lower-carbon energy is creating huge opportunities for manufacturers who supply the energy industry. Global investments worth over $300 billion annually for clean-energy goods ranging from solar panels and windmills to geothermal and biomass power equipment—not to mention upgraded systems for controlling energy flows and transporting energy carriers—are at stake. Innovation will be a key competitive advantage for the United States as these markets develop over the coming decades.[8]

Innovation mercantilism by foreign competitors, including the acquisition of promising U.S. government-funded energy start-ups, with follow-on manufacturing investment occurring in the foreign country, is a major threat to this advantage. Such acquisitions, it should be noted, are frequently aided by foreign government funds. In a competitive world in which such practices tilt the playing field, U.S. taxpayers have a right to insist that they receive benefits of their investments, rather than free riders overseas. Acquisition of ARPA-E-funded companies by companies headquartered in countries practicing innovation mercantilism should be prohibited. Requirements for substantial U.S. manufacturing should, of course, be constrained by international obligations, including reciprocal arrangements with economic partners, but should be maintained even if the firm is acquired by a foreign company.

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[7] Hans Hellsmark et al., "The Role of Pilot and Demonstration Plants in Technology Development and Innovation Policy," *Research Policy* 45:1743–1761 (2016).

[8] Bloomberg New Energy Finance, "Clean Energy Investment Exceeded $300 Billion Once Again in 2018," January 16, 2019, https://about.bnef.com/blog/clean-energy-investment-exceeded-300-billion-2018/

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About ITIF

ITIF is an independent nonprofit, nonpartisan research and educational institute—a think tank—founded in 2006. ITIF's mission is to formulate, evaluate, and promote policy solutions that accelerate innovation and boost productivity to spur growth, opportunity, and progress. ITIF adheres to a high standard of research integrity with an internal code of ethics grounded in analytical rigor, policy pragmatism, and independence from external direction or bias.[9] ITIF falls into group 3 among those listed on page 5 of the RFI: industry stakeholder.

ITIF's Clean Energy Innovation Policy Project seeks to accelerate the transition of the domestic and global energy systems to low-carbon resources by providing nonpartisan analysis of public policy, generating new public policy proposals, and convening members of the analytical and policymaking communities. The central goal of the project is to deepen the analytic case for clean energy innovation policy. ITIF has taken a strong interest in the operations and effectiveness of ARPA-E since the agency was first proposed, which continues today. This response to ARPA-E's RFI draws on this focused research as well as our work on innovation and energy innovation in general.

[9] For further information about ITIF, please visit our website at https:/itif.org/about.