THE ROLE OF ARPA-E IN REVOLUTIONIZING ENERGY RESEARCH

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Introduction

ARPA-E was established to bring a freshness, excitement, and sense of mission to energy research, and to attract many of the U.S.'s best and brightest minds- those of experienced scientists and engineers, and, especially, those of students and young researchers, including entrepreneurs and industry professionals. ARPA-E has a focus on creative "out-of-the-box" transformational energy research that industry by itself does not support, primarily due to its risk profile, but where success would provide tangible, near-term benefits for the nation.

ARPA-E is flat, nimble, and sparse, capable of executing those projects whose promise remains real, while phasing out programs that do not prove to be as promising as anticipated and creates a new tool to bridge the gap between basic energy research and development/industrial innovation. This talk will focus on various aspects of ARPA-E's programs and visions.

Origins

Recognizing the U.S. need to stimulate innovation and develop clean, affordable, and reliable energy, the National Academies recommended[1] the creation of ARPA-E as a catalyst to accelerate the development of transformational energy technologies. Modeled after the successful Defense Advanced Research Projects Agency (DARPA), ARPA-E was intended to take a high-risk and high-impact route to innovation in energy. Much like DARPA's creation in 1958 in response to the launch of the Russian Sputnik space satellite, ARPA-E was created with the realization that the U.S. was losing its technological lead, specifically in energy.

Through the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science (America COMPETES) Act, Congress authorized the creation of ARPA-E in 2007. ARPA-E received initial funding of $400 million in FY2009 to accelerate the pace of innovation and to fund early-stage transformational energy research that industry by itself is unlikely to support because of technical and financial uncertainty.

ARPA-E is purposefully organized and administered to ensure agility, allowing the Agency to quickly implement changes in its processes to improve both efficiency and effectiveness. Through a forward-thinking operation style, ARPA-E strives to be a model of excellence as a small agency within the U.S. government.

Technology Investment Model

ARPA-E invests in and manages the development of only transformational energy technologies that hold the potential to radically shift our Nation's energy reality. Transformational technologies are by definition those that disrupt the status quo. They do not seek evolutionary improvements—they drive revolutionary ones. They do not merely outperform current technologies—they make those technologies obsolete. ARPA-E aims to accelerate the development of transformational energy technologies at an early stage in their development cycle. Most ARPA-E funded projects range from technology concept (TRL 2) through component validation in laboratory experiment (TRL 4) technology readiness levels (TRL), a widely used systematic measurement system that assesses technology maturity. The TRL space between TRL 2 and TRL 4 is known as a "valley of death" for technology development: many private and public sector funders consider this nascent stage of development too high-risk for investment, even in concepts with promising technological potential.

To mitigate this risk, ARPA-E ensures its funding programs have commercial relevance—first, by considering potential market impact when developing new programs, and second, by incorporating market-relevant cost and performance criteria into each funding solicitation and the subsequent review and selection process. ARPA-E is specifically designed to assume and carefully manage this risk, providing crucial financial, technical, and commercialization assistance to a diverse portfolio of projects. Additionally, ARPA-E performs active program management on its projects including monitoring quarterly technical milestones, visiting project sites frequently, and utilizing go/no-go decisions for project advancement. ARPA-E aims to promote the rapid development of technologies toward a point where private or public investors commit funds and bring them to market scale. With ARPA-E funding and support, projects typically advance to component validation in a relevant environment (TRL 5) through system prototype demonstration in an operational environment (TRL 7).

Program Creation, Selection, and Management

ARPA-E's foundation rests upon open discussion across science, technology, and business. ARPA-E programs are created through a process of rigorous debate surrounding the technical/scientific merits and challenges of potential research areas and must satisfy both concepts of "technology push"—the technical merit of innovative platform technologies that can be applied to energy systems—and "market pull"—the potential market impact and cost-effectiveness of the technology.

The detailed program creation process begins with a "deep dive": a process of thoroughly exploring an aspect of the energy problem to identify potential topics for program development. ARPA-E Program Directors then hold technical workshops to gather input from the world's leading experts about current state-of-the-art technologies and new technological opportunities that lie on the horizon. By bringing together experts from all walks of science, technology, and business, ARPA-E breaks down silos between disciplines. This cross-disciplinary inquiry is essential to bridge the gap between basic and applied research and development. ARPA-E workshops bring together the best and the brightest to identify technical challenges and opportunities that connect science to technology and markets— linking knowledge of what science is capable of to what technology can achieve and what the market needs.

Following each workshop, the Program Director proposes a new program and defends the program against a set of criteria that justifies its creation. After intense, "constructive confrontation" and debate involving all ARPA-E Program Directors, the Program Director refines the program, incorporating internal and external feedback, and seeks approval from the Director. If successful, a new ARPA-E program is created, and a solicitation, or funding opportunity announcement (FOA), is released, soliciting project proposals.

With project proposals in hand, the ARPA-E peer review process is designed to help drive toward subsequent program success. During proposal review, ARPA-E solicits external inputs to make sure that it is funding the best technologies. ARPA-E taps the expertise of dozens of the leading experts in the world in a particular

field for in-depth proposal reviews. The involvement of world-class scientists, engineers, and leaders from the technical community brings expertise and knowledge to the process. ARPA-E reviewers evaluate applications over several weeks, and then come together for a review panel.

One notable facet of ARPA-E's evaluation process is the opportunity for the applicant to read reviewers' comments and to provide a rebuttal that the Agency reviews before making funding decisions. The applicant response period allows ARPA-E to avoid misunderstandings by asking clarifying questions that enable ARPA-E to make the most informed decisions during the project selection process and identify the most compelling and meritorious ideas for support.

The Program Directors actively participate in managing projects, working with project award recipients to help solve technical problems and to keep projects moving on their development track. When projects fail to meet technical milestones, the Program Directors carefully consider steps to improve performance, and may ultimately decide to recommend project termination and the redeployment of funds to those projects that show greater promise. The Director and Deputy Directors hold Program Directors accountable and review program direction regularly. Through these actions, ARPA-E acts as a responsible steward of the financial resources entrusted to it by taxpayers.

Program Portfolio

ARPA-E accomplishes its mission by funding research and development at existing research laboratories, at national laboratories, universities, small businesses, large businesses, and non-profit organizations.

ARPA-E's first open FOA was released in April 2009 and was open to all potentially disruptive energy technologies. Expecting 500 to 800 concept papers, the Agency received an overwhelming response of roughly 3,700 concept papers. ARPA-E invited the Nation's experts from academia, industry, and government to assist with reviewing the concept papers, and hundreds of reviewers participated. ARPA-E funded 36 projects from this open FOA totaling $150 million. Projects selected for funding fall across the energy landscape, including projects for Energy Storage; Biomass Energy; Carbon Capture; Renewable Power; Solar Fuels; Vehicle Technologies; Waste Heat Capture; Building Efficiency; Conventional Energy; and Water.

The second round of FOAs, announced in December 2009, focused on three new program areas known as Batteries for Electrical Energy Storage in Transportation (BEEST), Innovative Materials and Processes for Carbon Capture Technologies (IMPACCT), and Electrofuels. In April 2010, ARPA-E announced project selections for these program areas. 38 projects were awarded a total of $113 million.

In March 2010, ARPA-E announced its third round of funding opportunities and created programs that are known as: Grid-Scale Rampable Intermittent Dispatchable Storage (GRIDS), Building Energy Efficiency Through Innovative Thermodevices (BEETIT), and Agile Delivery of Electrical Power Technology (ADEPT). The project selections were announced in July 2010, and 42 projects are funded in these three programs with a total of $94 million. In August of that year, ARPA-E selected five additional projects for funding totaling $9 million that fell into the categories of Buidling Efficiency, Vehicle Technologies, Renewable Power, and Energy Storage.

The most recent round of funding was announced in April 2011 and included the following programs: Plants Engineered To Replace Oil (PETRO), Rare Earth Alternatives in Critical Technologies for Energy (REACT), High Energy Advanced Thermal Storage (HEATS), Green Electricity Network Integration (GENI), and Solar Agile Delivery of Electrical Power Technology (Solar ADEPT). Project selections were announced in September 2011.

References

(1)   National Research Council. *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. Washington, DC: The National Academies Press, 2007.