



Advanced Research Projects Agency-Energy Spurs Innovation and Market Growth

Federal investment in scientific discovery and technology is vital to maintaining U.S. economic leadership globally and in growing such key emerging sectors as clean energy

Overview

By capitalizing on America's greatest competitive advantages—innovation and entrepreneurship—initiatives such as the Department of Energy's Advanced Research Project Agency-Energy (ARPA-E) are accelerating the invention and development of cutting-edge processes and products that will revolutionize the electricity industry.

In 2007, Congress passed and President George W. Bush signed into law the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act (better known as the America COMPETES Act). The legislation authorized the ARPA-E program along with several other national research and development initiatives aimed at improving U.S. competitiveness.¹ Although the program has demonstrated success in helping early-stage technology make the transition into successful startup companies, government funding in this and other energy research and development (R&D) programs remains low relative to the defense and health sectors.² Competition from countries such as China, Japan, and the United Kingdom in creation of clean energy technologies makes increased federal investment imperative.³

Stages of Innovation

The introduction of advanced ideas, devices, or processes drives the emergence and creation of market sectors and supports the U.S. economy. The three stages of progression for discovery and invention are:

- **Basic science and early stage R&D.** Fundamental exploration to acquire new knowledge of materials and processes leading to novel theories and products.
- **Applied research.** Establishment of state-of-the-art concepts and prototype advancements, and exploration of the feasibility of scaling up these modern commodities.
- **Technology maturation and deployment.** Evaluation of materials, components, and efficiencies to optimize performance, demonstrate concepts, and support market adoption.

Rethinking energy from the ground up

In 1958, recognizing the need to realign science and applied research to meet America's security challenges, the Defense Department created the Defense Advanced Research Projects Agency (DARPA). Since then, the program has been responsible for groundbreaking technologies such as stealth fighter jets, GPS, and the foundation for the Internet.⁴ In light of the changing energy landscape and increasing international competition, ARPA-E-modeled on DARPA's success-was created to focus on similar transformational activities in the energy sector.⁵

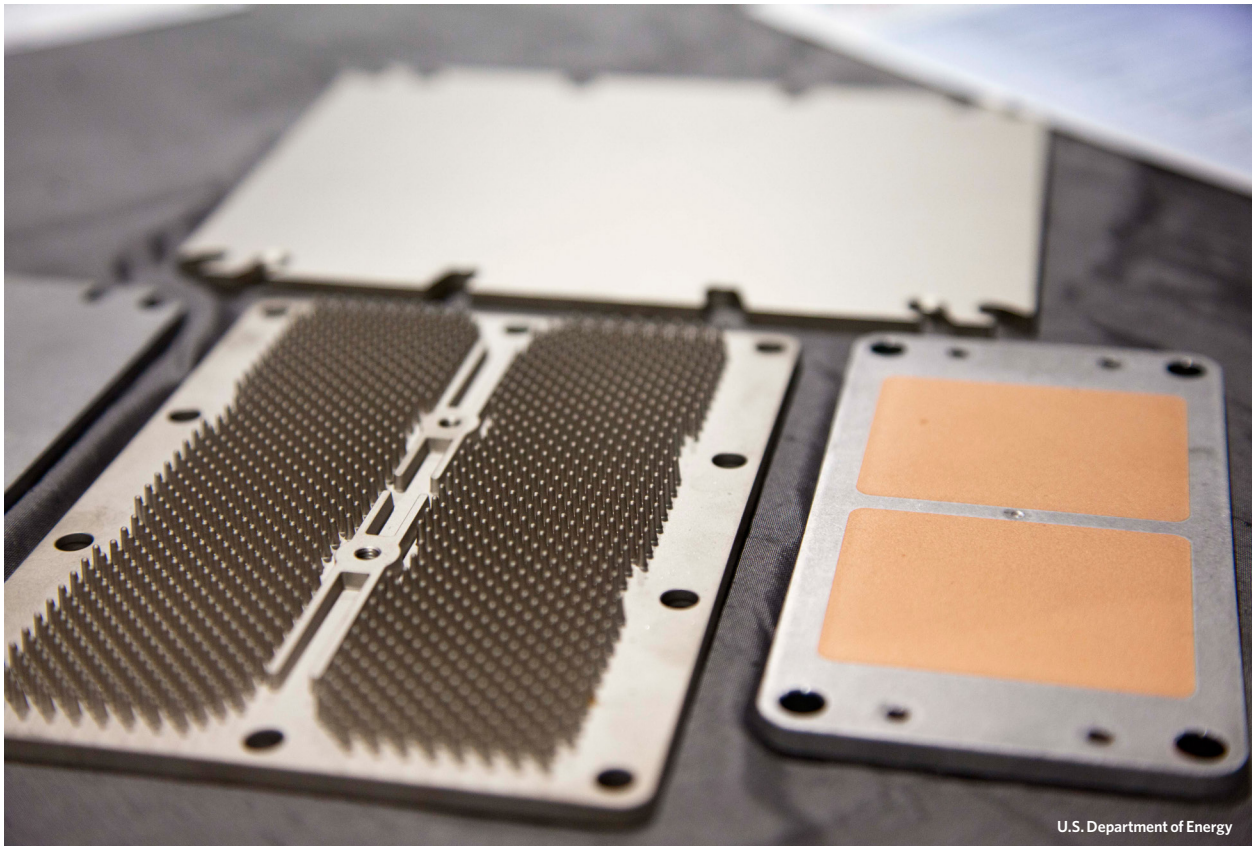
Operated by DOE, the program promotes technical achievements that can revamp the way power is generated, stored, and used. Through extensive engagement with experts, ARPA-E establishes a variety of challenges for the private sector and academia to rapidly advance experimentation to marketplace processes.⁶ Unlike R&D programs that focus on incremental research, ARPA-E achieves game-changing results in the clean energy sector through a dynamic organizational approach.

ARPA-E advances technologies of high potential and impact that are too early in development for private-sector investment. The program uses rigorous design and active management processes to ensure critical outcomes. Awardees are unique because they are inventing entirely new ways to generate, store, and use energy. Through competitive selection, ARPA-E seeks projects that can be meaningfully advanced with a small investment over a

defined period of time. It also provides streamlined awards, which enable it to act quickly and catalyze cutting-edge areas of energy research. To ensure a constant infusion of fresh thinking and new perspectives, national experts are appointed as managers for limited tenures.⁷

ARPA-E facilitates the transition of technology to commercial viability

Developing a process or device is one part of the equation for successful technology adoption; demonstrating economic viability is another. The DOE mandates that grantees devise a tech-to-market plan—a road map of activities to assess and speed the transition out of the laboratory.⁸ Requiring awardees to think critically about a project's end use leads to expeditious deployment in the private sector.



Heat sink plate designs by CPS Technologies that can be used in trains and hybrid electric vehicles.

The program also provides a platform for funded projects to showcase the use and viability of new products. The annual **Energy Innovation Summit** is an opportunity for researchers, entrepreneurs, financiers, corporate executives, and government officials to exchange ideas for developing and deploying the next generation of clean and efficient technologies. Participants engage with one another during the event, fostering collaborations among industry leaders.

U.S. companies thrive after working with ARPA-E

ARPA-E financing has led to groundbreaking advances in electricity storage, expanding the potential of clean energy to compete with traditional power plants.

Ambri

Ambri, formerly known as Liquid Metal Battery Corp., received nearly \$7 million in 2009 to design batteries that can store excess electricity. Ambri's liquid metal battery, which has a simple design, is less expensive than many other grid storage options currently available.^{*} In addition to ARPA-E funding, the company drew \$35 million in investment from KLP Enterprises and received private support from the global energy company Total World Energy, the venture capital firm Khosla Ventures, and Microsoft founder Bill Gates.[†] Using these monies, the company opened its first battery manufacturing factory in Massachusetts in 2013 with the goal of constructing a prototype by 2015.[‡]

1366 Technologies

1366 Technologies (named after a scientific unit of measure describing the total solar radiation received from the sun) was awarded \$4 million in ARPA-E funding in 2009 to support development of solar wafers, a critical hardware component in photovoltaic panels used to turn sunlight into electricity.[§] The company, which aims to deliver solar at the cost of coal, developed a streamlined manufacturing process that cuts in half the cost of generating these cells. By 2014, it had raised over \$60 million in follow-on funding from the private sector and opened a new facility to help commercialize the product.^{**} In 2011, the business was selected as one of the Massachusetts Institute of Technology's Top 50 Most Innovative Companies, and it won the New Energy Pioneer Award from Bloomberg New Energy Finance.

^{*} Ambri, "Origins" (2014), <http://www.ambri.com/company/>.

[†] Ambri, "Ambri Raises \$35 Million in Series C Round," (April 30, 2014), http://www.ambri.com/storage/documents/press/20140430_Ambri_Raises_35_Million_in_Series_C_Round.pdf.

[‡] Katie Fehrenbacher, "Ambri Launches its First Factory to Make Liquid Metal Batteries," Gigaom (Nov. 7, 2013), <https://gigaom.com/2013/11/07/ambri-launches-its-first-factory-to-make-liquid-metal-batteries/>.

[§]1366 Technologies, "1366 Technologies Awarded Four Million in ARPA-E Funding," <http://1366tech.com/1366-technologies-awarded-four-million-in-arpa-e-funding/>.

^{**} 1366 Technologies, "1366 Technologies Secures \$15M in Series C Funding to Drive Next Phase of Growth," <http://1366tech.com/1366-technologies-secures-15m-in-series-c-funding-to-drive-next-phase-of-growth/>; 1366 Technologies, "1366 Technologies Celebrates Opening of New Manufacturing Facility," <http://1366tech.com/1366-technologies-celebrates-opening-of-new-manufacturing-facility/>.

Markets grow from ARPA-E investments

ARPA-E has spurred the formation of numerous startup and spinoff businesses and is a major contributor to keeping the U.S. globally competitive in the clean energy economy. Since its launch, ARPA-E has backed more than 360 projects, many of which are demonstrating early indicators of technical success and have been the beneficiaries of additional private-sector funding. In 2014, the agency financed techniques to manufacture lightweight metals, design robust battery chemistries for electric vehicles, biologically transform natural gas to liquids, and deliver solar energy when the sun is not shining.⁹

A key focus area of ARPA-E is addressing the electric grid's limited ability to store excess electricity. Transmission system inefficiencies and the periodic nature of renewable resources such as wind and solar can create reliability challenges. The initiative has invested in a variety of promising technologies that could overcome these barriers, including cheaper batteries that can store more energy and increase predictability for grid operators.

ARPA-E by the Numbers

Key Statistics	
\$900 million	Investment in energy technologies
360	Number of projects that have received funding
\$625 million	Amount of private-sector follow-on financing attracted by top 22 projects
24	Number of projects that have formed new companies
16	Number of projects that have partnered with other government agencies

Source: Advanced Research Project Agency-Energy, "ARPA-E Projects Attract More Than \$625 Million in Private Funding," U.S. Department of Energy (Feb. 25, 2014), <http://arpa-e.energy.gov/?q=arpa-e-news-item/arpa-e-projects-attract-more-625-million-private-funding>.

© 2015 The Pew Charitable Trusts

For the U.S. to compete in the global clean energy race, funding such as that provided by ARPA-E—which allows companies to explore new technologies, develop products, create jobs, and support the domestic economy—is essential. The U.S. needs to prioritize investment in energy innovation, as it has done for health and defense research, to ensure continued market competitiveness for U.S. researchers, developers, and manufacturers.

For more information on the role these programs play in supporting technology innovation and market deployment, see the following links:

- **Advanced Research Project Agency-Energy (ARPA-E)**
- **Defense Advanced Research Projects Agency (DARPA)**
- **Department of Energy**

Endnotes

- 1 Advanced Research Project Agency-Energy, "ARPA-E History," U.S. Department of Energy, <http://arpa-e.energy.gov/?q=arpa-e-site-page/arpa-e-history>.
- 2 J.J. Dooley, *U.S. Federal Investments in Energy R&D: 1961-2008* (2008), U.S. Department of Energy, http://www.wired.com/images_blogs/wiredscience/2009/08/federal-investment-in-energy-rd-2008.pdf.
- 3 The Pew Charitable Trusts, *Who's Winning the Clean Energy Race? 2013*, (2014), <http://www.pewtrusts.org/-/media/Assets/2014/04/01/clewhoswinningthecleanenergyrace2013pdf.pdf>.
- 4 Defense Advanced Research Projects Agency, "History," <http://www.darpa.mil/About/History/History.aspx>.
- 5 Advanced Research Project Agency-Energy, "ARPA-E History."
- 6 Advanced Research Project Agency-Energy, "Frequently Asked Questions," U.S. Department of Energy, <http://arpa-e.energy.gov/?q=faq>.
- 7 Advanced Research Project Agency-Energy, "Authorization," U.S. Department of Energy, <http://arpa-e.energy.gov/?q=arpa-e-site-page/authorization>.
- 8 Advanced Research Project Agency-Energy, "Tech-To-Market (T2M)," U.S. Department of Energy, <http://arpa-e.energy.gov/?q=arpa-e-site-page/tech-market-t2m>.
- 9 Advanced Research Project Agency-Energy, "ARPA-E History."

For further information, please visit:

pewtrusts.org/cleanenergy

Contact: Kerry Schlichting, senior associate
Email: kschlichting@pewtrusts.org
Phone: 202-540-6328

The Pew Charitable Trusts is driven by the power of knowledge to solve today's most challenging problems. Pew applies a rigorous, analytical approach to improve public policy, inform the public, and invigorate civic life.