



SUBCOMMITTEE ON ENERGY

HEARING CHARTER

“Bridging the Valley of Death: ARPA-E's Role in Developing Breakthrough Technologies”

Tuesday, March 12, 2024

10:00 a.m.

2318 Rayburn House Office Building

Purpose

The purpose of this hearing is to explore the Department of Energy’s (DOE) Advanced Research Projects Agency - Energy (ARPA-E) program, how it helps accelerate the development of cutting-edge energy technologies, and how Congress may reform ARPA-E to further align with DOE’s main mission.

Witnesses

- **The Honorable Lane Genatowski**, Former Director, ARPA-E, U.S. Department of Energy
- **Tim Lust**, Chief Executive Officer, National Sorghum Producers
- **Dr. Tim Held**, Chief Technical Officer, Echogen Power Systems
- **Dr. Ryan Umstatted**, Vice President, Product & Partnerships, Zap Energy

Overarching Questions

- How can ARPA-E and the federal government better support development of technologies through innovative start-ups during their award and ensure successful post-award scale-up to commercialization?
- What percentage of ARPA-E awardees have access to private capital for their research before, during, and after their selection?
- Is ARPA-E’s current work duplicative with DOE’s other applied research offices? If so, what reforms could be put in place to prevent this duplication?
- Do ARPA-E participants struggle with red tape/bureaucracy because of how it is structured to take risks and what can Congress do to better address this different approach compared to DOE’s traditional investments?

Background

In 2005, the National Academies of Sciences (NAS) published, "Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future," in response to a Congressional request to identify federal actions that could enhance science and technology.¹ The report recommended that the United States should "sustain and strengthen the nation's traditional commitment to long-term basic research that has the potential to be transformational to maintain the flow of new ideas that fuel the economy, provide security, and enhance the quality of life."²

Additionally, the NAS report recommended establishing an agency similar to the Defense Advanced Research Projects Agency (DARPA) within DOE. This agency was intended to enable creative and cutting-edge energy research that American industry could not support – in which risks are high but successes could have wide-ranging impacts on critical American economic, environmental, and national security challenges.³

Following this report, ARPA-E was formally established under the America COMPETES Act, which was signed into law by President George W. Bush in 2007. This legislation defines the goals of ARPA-E, which are to enhance the economic and energy security of the United States, primarily through the reduction of reliance on foreign sources of energy and energy related emissions, and through the improvement of energy efficiency in all economic sectors.⁴

In line with NAS recommendations, the COMPETES Act required ARPA-E to achieve these goals by identifying and promoting innovative advances in basic science research, translating these advances and inventions into technological innovations, and focusing on areas and issues that have such high technical or financial risk that private industry is not likely to pursue them.⁵ The agency was last updated through reauthorization in the Energy Act of 2020.

Compared to other agencies within DOE, ARPA-E is unique in its hiring practices and programmatic approach. Like DARPA, ARPA-E attracts talent from industry, the National Laboratories, and universities to serve as program directors. These experts' positions are limited to three to five years, which incentivizes a "move fast and break things" approach to innovation.

In addition, ARPA-E's programs greatly differ from the traditional programmatic approach in the applied and fundamental science programs. Given the directors' term lengths, ARPA-E's programs are short, lasting only a few years. As a result, they are highly responsive to technological innovation and market trends, which is highly conducive to innovation.⁶ ARPA-E offers two types of programs: open and focused. Open programs solicit applications for any idea that has the potential to be transformational, while focused programs address a specific energy challenge.

¹ Augustine, Norman R., et al., eds. *Rising Above the Gathering Storm*, National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 9 Nov. 2005, www.nsf.gov/attachments/105652/public/NAS-Gathering-Storm-11463.pdf.

² *Id.*

³ *Id.*

⁴ "H.R.2272 - 110th Congress (2007-2008): America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act." *Congress.gov*, Library of Congress, 9 August 2007, <https://www.congress.gov/bill/110th-congress/house-bill/2272>.

⁵ *Id.*

⁶ "ARPA-e Strategic Vision Roadmap." *Arpa e*, 8 Aug. 2022, arpa-e.energy.gov/sites/default/files/2022_ARPA-E_Strategic_Vision_Roadmap.pdf.

Through this model, ARPA-E can fill the gaps in the development cycle and bet on highly disruptive technologies such as fusion energy systems.

ARPA-E's initial \$400 million budget in 2009 was more than halved for FY2011 but increased steadily throughout the rest of the 2010s under both the Obama and Trump Administrations. The Biden Administration continued the trend of increasing funding by allocating \$450 million and \$470 million to the program for FY2022 and FY2023, respectively.⁷

ARPA-E's FY2023 budget request was \$700 million which was 49% more than what was ultimately enacted at \$470 million. By comparison, DARPA requested \$4.1 billion for FY2023. ARPA-H (Health) followed with a \$5 billion request and ARPA-I (Infrastructure) requested just \$3.2 million.⁸ In FY2024, ARPA-E requested \$650 million, with the Energy & Water Conference Report language released on March 3, 2024, designating \$460 million to the program.

As of January 2024, ARPA-E has provided \$3.76 billion in research and development funding to more than 1,560 projects. Twenty-nine program exits worth \$21.9 billion have resulted in 154 company formations, over 1,100 patents, and over 400 licenses.⁹ The year 2023 saw ARPA-E produce the first industry-certified decarbonized cement, the first seaweed research in federal waters, and the first commercial direct air capture (DAC) facility, among others.¹⁰

ARPA-E Investments in Agriculture

Agriculture research as it relates to energy is one area of innovation that ARPA-E has achieved noted success on. Through its Transportation Energy Resources from Renewable Agriculture (TERRA) program, ARPA-E has facilitated the improvement of advanced biofuel crops, specifically sorghum, by developing and integrating cutting-edge remote sensing platforms, complex data analytics tools, and high-throughput plant breeding technologies. Sorghum, a flowering plant in the grass family, is unique in its capabilities as a biofuel and its use as a conservation tool both for soil and wildlife.¹¹

TERRA also generated the world's largest public reference database of sorghum plant characteristics and genetic composition. This will enable research and development efforts in both the public and private sectors and in other crops. The TERRA program allowed researchers to construct automated methods to accurately measure and analyze crop growth, characterize genetic potential, and develop processes for picking the best plants. These advancements help domestic production of sustainable and affordable liquid fuels.¹²

Programs like this are essential in the development of agricultural crops being used for a variety of purposes outside their traditional roles. The TERRA program's goals were to develop tools used for genetic improvement and yield of crops grown in the field. Most importantly, innovations from

⁷ "Budget Requests." *Arpa e*, 25 Feb. 2013, arpa-e.energy.gov/about/budget-requests.

⁸ "The Biden-Harris Administration FY 2023 Budget Makes Historic Investments in Science and Technology." *The White House*, The United States Government, 5 Apr. 2022, www.whitehouse.gov/ostp/news-updates/2022/04/05/the-biden-harris-administration-fy-2023-budget-makes-historic-investments-in-science-and-technology/.

⁹ "Our Impact." *Arpa e*, 15 May 2018, arpa-e.energy.gov/about/our-impact.

¹⁰ "2023 Impact Card." *Arpa e*, 2 Jan. 2024, arpa-e.energy.gov/about/our-impact/2023-impact-card.

¹¹ "Climate Smart Sustainability." *National Sorghum Producers*, 26 Apr. 2023, sorghumgrowers.com/sustainability/.

¹² "E's Terra Program: Transportation Energy Resources from Renewable Agriculture." *Arpa e*, 1 Oct. 2014, arpa-e.energy.gov/technologies/programs/terra.

the program allowed breeders to evaluate more individual plants, detect the most promising plants earlier in the season, get better information from plants throughout the season, and then use that to develop the best new varieties. Typical breeding normally takes decades to achieve the same result, because the processes involved are often very time-intensive, imprecise, and done manually. Advanced technologies that increase plant screening and the identification of genetic markers for wanted traits, like those developed through ARPA-E, can be used to generate more precise and complete sets of data, dramatically speeding up the process and the development of enhanced biofuel crops.

Another program funded by ARPA-E was the Rhizosphere Observations Optimizing Terrestrial Sequestration (ROOTS) which looked to develop breeding technologies to increase soil carbon while also decreasing nitrous oxide emissions. Maintaining good soil carbon levels is essential to farm productivity which increases long-term profitability. Sorghum was also used in this program because of its unique capabilities compared to other crops, such as its increased efficiency to sequester carbon into the soil and reduced requirement for tilling.¹³ This allows sorghum stalks to be left standing in the field as crop residue, keeping nutrients in the soil, breaking up soil compaction, increasing moisture retention, and decreasing effects of wind erosion.¹⁴

ARPA-E Investments in Energy Storage

ARPA-E has made significant investments in energy storage. The Duration Addition to electricity Storage (DAYS) program was started to develop energy storage systems that could provide power to the grid for between 10 and 100 hours.¹⁵ This window would allow new scientific opportunities for both grid resiliency and performance. Most of the previous research in this sector was limited to much shorter time frames focused on a separate set of problems.

DAYS is tackling a new set of applications like long-lasting backup power and the integration of renewable resources on the grid. The program is also expanding its research into increasing stored energy and extending the duration of stationary electricity storage systems. These types of storage systems are critical for hydroelectric power and will continue to be important as additional energy supplies are added to the grid.

Long duration storage research is also being done to determine how intermittent sources like wind and solar can efficiently integrate into the grid. Energy storage for the transportation and electricity sectors has rapidly developed with the advancements of electric vehicles and the need for large scale energy storage. For stationary applications (grid, microgrid, or off-grid), the high initial capital costs are proving to be a hurdle that is limiting widespread deployment of these types of systems. ARPA-E's programs work to address these problems by looking at all the possible technology pathways that may help in bringing down these costs to allow for energy storage systems to be commercialized.

In addition to DAYS, the FLExible Carbon Capture and Storage (FLECCS) program develops carbon capture and storage (CCS) technologies that enable power generators to be responsive to grid conditions in a high variable renewable energy (VRE) penetration environment. FLECCS is a

¹³ "Climate Smart Sustainability." *National Sorghum Producers*, 26 Apr. 2023, sorghumgrowers.com/sustainability/.

¹⁴ *Id.*

¹⁵ "E's Days Program: Duration Addition to Electricity Storage." *Arpa e*, 1 May 2018, arpa-e.energy.gov/technologies/programs/days.

2-phase program. Phase 1 selected 12 projects focused on designing and optimizing innovative CCS processes that enable flexibility on a high-VRE grid. Phase 2 selected six projects to continue and focuses on building components, unit operations, and small prototype systems to reduce the technical risk and cost associated with these CCS systems. This phase will last for approximately three years and has a total budget of \$31 million.^{16,17}

ARPA-E Investments in Fusion Power

Over the past few years, the U.S. fusion energy industry has greatly expanded. Out of the 37 fusion companies that make up the Fusion Industry Association, the U.S. has 24 members.¹⁸ Some of this enthusiasm is because ARPA-E has prioritized several projects around nuclear fusion technologies. Successful and sustainable fusion energy generation would revolutionize clean energy production by allowing for consistent production regardless of the weather or time of day.

ARPA-E has launched several programs designed to help further technologies around fusion and tackle some of the issues the industry still faces. The ALPHA program was intended to design tools that create new low-cost pathways that would accelerate the progress of fusion research and development.¹⁹ The Galvanizing Advances in Market-Aligned Fusion for an Overabundance of Watts (GAMOW) program was uniquely paired between ARPA-E and the Office of Science's Fusion Energy Sciences program for the combination of funding and expertise from the two offices.²⁰ The Breakthroughs Enabling Thermonuclear-fusion Energy (BETHE) program supports lower-cost fusion options in three different research categories, each category targeting the various levels of maturity for systems. These classes cover the breadth of the fusion space with the goal of delivering a larger number of high maturity fusion systems to fruition.²¹

The three programs mentioned previously are not the only fusion energy funding that ARPA-E provides. Other proposals, some of which are in the general fusion project space, have received funding during ARPA-E's occasional open calls, with the most recent opportunities in the Open 2018 and Open 2021.²² All of these investments are working to solve the challenges of getting fusion energy to market and enable startup fusion companies to be successful.

¹⁶ "E's FLECCS Program: Flexible Carbon Capture and Storage (FLECCS)." *Arpa e*, 14 Nov. 2019, arpa-e.energy.gov/technologies/programs/fleccs.

¹⁷ "The Arpa-E FLECCS Program." *Arpa e*, 25 Jan. 2022, arpa-e.energy.gov/sites/default/files/2022-01/01%20-%20Litzelman%20overview.pdf.

¹⁸ *Fusion Industry Association*, 30 May 2023, www.fusionindustryassociation.org/.

¹⁹ "E's Alpha Program: Accelerating Low-Cost Plasma Heating and Assembly." *Arpa e*, 24 Aug. 2014, arpa-e.energy.gov/technologies/programs/alpha.

²⁰ "E's Gamow Program: Galvanizing Advances in Market-Aligned Fusion for an Overabundance of Watts." *Arpa e*, 13 Feb. 2020, arpa-e.energy.gov/technologies/programs/gamow.

²¹ "E's Bethe Program: Breakthroughs Enabling Thermonuclear-Fusion Energy." *Arpa e*, 7 Nov. 2019, arpa-e.energy.gov/technologies/programs/bethe.

²² "E's Open 2018 Program: Open Funding Solicitation." *Arpa e*, 13 Dec. 2019, arpa-e.energy.gov/technologies/programs/open-2018.