

The Future of ARPA-E  
Testimony before the House Science, Space, and Technology Committee,  
Subcommittee on Energy  
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Chairman Lamb, Ranking Member Weber, and other distinguished Members of the Energy Subcommittee of the House Science, Space, and Technology Committee, thank you for the opportunity to testify about ARPA-E.

My testimony today is guided by my career working on energy efficiency and environmental technologies at Chevron and Cummins, including 15 years as Cummins Chief Technical Officer. In addition, I served on a recent National Academies of Sciences, Engineering, and Medicine study committee tasked with assessing the first six years of ARPA-E.

The ARPA-E study committee

As this committee is well aware, the National Academies' assessment of ARPA-E was mandated in the authorizing legislation. The study committee was asked to conduct an assessment of the progress the agency made toward achieving its congressionally mandated mission and goals. The committee was composed of a diverse set of members, including academic and industry engineers (such as myself) and scientists, academic economists and statisticians, experts from private research organizations, and former government officials.

The committee concluded that there were clear indicators that ARPA-E is making progress toward its statutory mission and goals, while understanding it could not reasonably be expected to have completed fulfilled those goals given so few years of operation and the size of its budget.

I would also like to note that the idea of ARPA-E sprang from a recommendation in a 2007 National Academies' report, *Rising Above the Gathering Storm: Energizing and Employing America for a Bright Economic Future*. In the Gathering Storm report, the committee recommended that the federal government create a DARPA-like organization within the Department of Energy charged with sponsoring specific R&D programs to meet the Nation's long-term energy challenges and creating an opportunity for "out-of-the-box" transformational research.

Despite the fact that the genesis of the idea came from within the National Academies, the study committee that I served on conducted an independent and unbiased assessment of ARPA-E.

I would like to make three main points today.

First,

**ARPA-E plays a unique and vital role in US energy innovation, beyond what industry can do for itself.**

From my personal experience, I can tell you that innovation in energy happens across a broad spectrum – from novel, unproven hypotheses to concept validation to integration into products that are then bought and used by customers. Innovation only has value if it makes it all the way into use.

Required investments grow through this progression from thousands to millions to hundreds of millions of dollars from unproven concepts to productionized manufacturing. “Derisking” of novel concepts is a very important element of this development process to allow for rational business investment in product development and manufacture.

A manufacturing company is not equipped to do all the research required for breakthrough and disruptive innovation internally. In fact, they might not even recognize it when it’s first happening. But they can embrace it, scale it up, and bring it to market once it’s validated.

For example: In 2019, Cummins is celebrating its 100<sup>th</sup> year in the diesel engine business and also is introducing its first all-electric powertrain. While Cummins was innovating in the diesel engine space, those electric powertrain technologies were being developed and validated independently by innovators with unique skills that Cummins simply did not possess. But they have now been brought into the company for integration into a new product line.

My experience in industry was echoed in the findings of our National Academies report, where we found that

“One of ARPA-E’s strengths is its focus on funding high-risk, potentially transformative technologies and overlooked, “off-roadmap” opportunities pursued by neither private firms nor other funding agencies, including other programs and offices within DoE.” (NASEM report on ARPA-E, Finding 4-4).

and

“ARPA-E has funded research that no other funder was supporting at the time. The results of some of these projects have prompted follow-on funding for various technologies, which are now beginning to enter the commercial market.” (NASEM report on ARPA-E, Finding 4-1)

ARPA-E has established an organization to facilitate technology development and transfer like this, with culture and talent specifically aimed at identifying promising concepts in critical energy areas and nurturing them to success.

The National Academies report documented the work done by ARPA-E to look for perceived gaps or opportunities in the energy technology landscape. ARPA-E searches for technological approaches that are truly novel or greatly underexplored, and searches to fill gaps left in other research or funding programs. One example of this in the report is the Full-spectrum Optimized Conversion and Utilization of Sunlight (FOCUS) program which merged concentrating solar power and photovoltaic technologies to create a combined technology with lower cost per kilowatt hour than either technology alone. The report's case study appendix (Appendix D) highlights other effective programs as well.

But it's not just about funding.

This leads to my second main point.

**ARPA-E attracts individuals into relatively short-term government service as program managers with the specialized skills to evaluate hypotheses that can be quite arcane and to manage them forward.**

The National Academies committee also concentrated on ARPA-E's internal operations to appraise the effectiveness of its structure at achieving its mission and goals.

The committee found that the ARPA-E benefits from three defining organizational features:

1. The director exercises technical and leadership skills that enable a culture of empowerment to be sustained.
2. ARPA-E's program directors are empowered with the authority, responsibility, and ability to make program-and project-related decisions.
3. Active project management is important to ARPA-E.

The National Academies report found that

“ARPA-E program directors have wide authority to develop new focused technology programs that are potentially transformative.” (NASEM report on ARPA-E, Finding 3-8)

and

“ARPA-E program directors actively manage projects through technical research guidance and feedback, regular and frequent assessments of progress made toward stated technical milestones, and revision of milestones in response to new findings and research discoveries.” (NASEM report on ARPA-E, Finding 3-9)

Program directors are accorded wide latitude in identifying research themes; creating new programs; supervising projects; identifying commercial opportunities; and, when necessary, terminating projects.

And the program directors are specifically recruited for their technical domain knowledge.

Interviews with current and former ARPA-E program managers led the study committee to conclude that program managers found that working at ARPA-E allowed them to "work on truly revolutionary ideas or technologies" in contrast to private industry "where research is focused on supporting existing product lines and over short time spans." (NASEM report on ARPA-E, p. 57)

The National Academies also recommended that ARPA-E retain its practice of keeping program managers for short terms. "ARPA-E should continue its practice of hiring program directors for 3-year terms, allowing one, term-limited extension when necessary to complete implementation of a new program or for other reasons determined by the ARPA-E director." (NASEM report on ARPA-E, Recommendation 3-4).

So this is not "casting our bread on the water", it's "cultivating fish"!

Many of ARPA-E's internal processes were patterned after DARPA. The committee highlighted many of the similarities – and some differences – between ARPA-E and DARPA (NASEM report on ARPA-E, pp. 74-79). Both of the agencies have low levels of hierarchy, an organizational culture of risk taking, a focus on hiring highly qualified technical staff with academic and industrial backgrounds, and providing broad autonomy for program managers to identify and support relevant technologies.

There are a number of differences between the agencies, the largest and most important of which is the size of each agency's budget and the uncertainty surrounding whether it will be funded. As discussed in the National Academies' report, DARPA's annual budget is roughly 10 times that of ARPA-E, nor has DARPA experienced threats of having its budget reduced to 0 each year. This scale and certainty of funding allows DARPA to take a broader and longer-range view to supporting technology development.

Despite its smaller budget, my third point is that

### **ARPA-E supports US global competitiveness.**

Consider Cummins experience in China. Cummins entered the Chinese engine market very successfully based on world-class emission technology that far exceeded indigenous capability, and later moved on to a hybrid powertrain partnership with China government support. That support was abruptly terminated as China realized that the rest of the world was ahead in that domain, too, and shifted to a focus on battery electric vehicle powertrains with the strategic intent to lead the world in E.V. production.

As I was reflecting on this, I looked up the current China Five-Year Plan. Here's some of what I found:

(<http://en.ndrc.gov.cn/newsrelease/201612/P020161207645765233498.pdf>)

## *PART II INNOVATION-DRIVEN DEVELOPMENT*

*With innovation as the basis from which to pursue development, we will give a central role to innovation in science and technology and a supporting role to the development of talent, closely integrating scientific and technological innovation with business startups and innovation by the general public in order to achieve leading-edge development that relies more on innovation as its driver and offers greater incentives for first innovators.*

### *Chapter 6 Ensure Innovation in Science and Technology Takes a Leading Role*

*We will see that scientific and technological innovation leads the way in all areas of innovation. We will strengthen basic research, bolster primary innovation, innovation based on the integration of existing technologies, and innovation based on import and assimilation, and improve China's own capacity for innovation, so as to provide an inexhaustible driving force for economic and social development.*

#### *Section 1 Breakthroughs in Strategic and Frontier Fields*

*Chapter 6 Ensure Innovation in Science and Technology Takes a Leading Role*

*Chapter 7 Encourage Public Startups and Innovations*

*Chapter 8 Establish Innovation Promoting Institutions and Mechanisms*

*Chapter 23 Develop Strategic Emerging Industries*

*Chapter 30 Build a Modern Energy System*

*Chapter 48 Develop Green and Environmentally Friendly Industries*

This isn't their energy policy – it's the blueprint for all dimensions of their national policy – and it is heavily focused on innovation in energy.

Make no mistake about it -- we are in a race without a finish line. And it's a global race.

ARPA-E plays a critical role here

for American technology leadership,

for American business leadership,

for American jobs, especially high-tech jobs.

That's worth a billion-dollar investment in ARPA-E.

**I would also like to highlight a few recommendations for improvement of ARPA-E from the National Academies report, which were offered very much in the spirit of “you don’t have to be bad to get better”.**

ARPA-E should reconceptualize its “technology-to-market” (T2M) program to account for the wide variation in support needed across programs and performers with respect to prospective funding, commercialization, and deployment pathways. (NASEM report on ARPA-E, Recommendation 3-3)

The director of ARPA-E should continue to promote and maintain a high-risk culture within the agency. Means to this end include periodic reassessment to ensure that the principles that drive support for high-risk projects are being maintained. (NASEM report on ARPA-E, Recommendation 4-2)

The National Academies found that through its projects and programs, ARPA-E is accumulating not only technical knowledge of what is working and has promise, but also potentially very useful information on what does *not* work that can be an important addition to ARPA-E documentation (NASEM report on ARPA-E, Finding 4-7), and recommended that program managers compile a repository of lessons learned on all projects, included both positive and negative outcomes. (NASEM report on ARPA-E, Recommendation 4-6)

The National Academies also recommended that ARPA-E increase and improve its communication for non-technical audiences, which would help demonstrate how the projects and programs are working toward its stated mission and goals to a more general audience. (NASEM report on ARPA-E, Recommendation 4-7)

And finally, the National Academies’ report recommended that ARPA-E should consider streamlining some its reporting requirements to ease the burden on performers. (NASEM report on ARPA-E, Recommendation 4-5).

I ask that my full testimony and the Executive Summary of the National Academies 2017 report **An Assessment of ARPA-E** be submitted into the record. And I encourage the Committee and Subcommittee members and staff to read the full report.