The Advanced Research Projects Agency – Energy (ARPA-E)
Assessing Progress and Promise for Transforming U.S. Energy Innovation

Statement of

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before the

Committee on Science and Technology
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Mr. Chairman,

I am Charles Vest, President of the National Academy of Engineering and former president of MIT. The National Academy of Engineering is an elected body of 2,000 of the nation's most accomplished engineers from industry, academia, and government. We are charged by the Congress to serve as the key external advisors to the Federal Government on matters of engineering and technology. Together with our sister organizations, the National Academy of Sciences and the Institute of Medicine, we comprise the National Academies.

Thank you for the invitation to reflect on the early stages of the establishment of the Advanced Research Projects Agency – Energy (ARPA-E), the agency's progress to date, and its promise for filling an important gap in the nation's array of tools for energy research, development and innovation. This morning I would like to recap some of the key ideas motivating the creation of ARPA-E and note how those ideas were reflected in the 2007 America COMPETES Act and now, in the Department of Energy's implementation of ARPA-E. Finally, I would like to offer some thoughts on how the

intended features of ARPA-E might be preserved and nurtured as this new agency continues to mature.

Conceptual Foundations of ARPA-E

In 2006 I was privileged to serve on a National Academies committee chaired by Norm Augustine that produced the report, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. That report included many recommendations for rebuilding the nation's ability to utilize technology innovation as an engine for economic growth and international competitiveness, but it included only one recommendation to create a new government organization, ARPA-E, similar in design and intent to the very longstanding Defense Advanced Research Projects Agency (DARPA).

The Gathering Storm committee found a serious lack of either government or industry mechanisms for exploring long-term, high-risk, but potentially very high payoff energy research, development, and innovation directed specifically toward deploying new energy technologies. The committee concluded that creation of an ARPA-E was important to develop a base of "transformational research that could lead to new ways of fueling the nation and its economy." ARPA-E's mission would, in the committee's view, complement but not replace other mechanisms in the nation's energy R&D portfolio.

In particular, the Gathering Storm committee believed that a key reason to establish ARPA-E in the Department of Energy (DOE) was to attract and enable new elements of the scientific and engineering research and development communities from industry and academia to conduct high-risk, high-payoff, goal-oriented research that would not be carried out otherwise. The committee reasoned that ARPA-E should be a new entity that would support work outside the traditional venues such as the DOE laboratories. It would attract new players in universities and private industry, especially entrepreneurial enterprises. Key to its success would be how well the agency manages to gather bright project managers to conceive, stimulate, and fund non-traditional,

potentially high-payoff, goal-oriented R&D. The general framework provided by DARPA could help provide a time-proven point of departure for rapidly designing and deploying a lean, assertive organization with a high probability of being very important to the nation's energy future.

As an educator and a long time observer of the science and engineering communities, I note that, on the whole, in recent decades few of our most creative minds were attracted to energy research. We in universities, after the early 1980s, allowed energy to slip into academic backwaters. Neither our energy companies, nor our national laboratories, nor the entrepreneurial community applied the intellectual and financial attention the area deserved. With notable exceptions, we grew complacent while a monumental national and international challenge developed.

In the last three or four years, of course, the larger scientific and engineering communities have awakened to challenge of our looming energy crisis. I note that the study, *America's Energy Future: Technology and Transformation*, initiated in 2007 by the National Academy of Engineering and the National Academy of Sciences, and released last year, identified many of the key energy technology pathways essential to transforming the nation's patterns of energy supply and demand, including improving energy efficiency in buildings, transportation and industry, coal-fired electric power generation, nuclear power, renewable energy (principally in electric power generation), oil and natural gas, alternative liquid transportation fuels derived from coal and biomass, and modernization of the nation's electric power transmission and distribution grid.

The America's Energy Future study also characterized the challenges that must be addressed in developing those technology pathways and concluded that with a sustained national commitment, the United States could obtain substantial energy-efficiency improvements, new sources of energy, and reductions in greenhouse gas emissions through the accelerated deployment of existing and emerging technologies. However, mobilization of the public and private sectors, supported by sustained long-term policies and investments, will be required for the decades-long effort to develop, demonstrate, and

deploy these technologies. Actions taken between now and 2020 to develop and demonstrate several key technologies will also largely determine our options for many decades to come. Further, the study committee found that it is imperative that key technology development and demonstration activities be started very soon, even though some will be expensive and not all will be successful or will be overtaken by better technologies. In order to in develop these pathways, however, we must take concerted action and make the considerable investments necessary to enlist our most talented researchers and innovators. I believe that ARPA-E could play a considerable role in accelerating some of these transformations.

The Gathering Storm committee conceived of ARPA-E as a critically important organization reporting to the DOE Under Secretary for Science with four principal objectives:

1. Bring a freshness, excitement, and sense of mission to energy research that will attract many of our best and brightest minds – those of experienced scientists and engineers, and, especially, those of students, young researchers, and entrepreneurs.

2. Focus on creative, out-of-the-box, potentially transformational research that industry cannot or will not support.

3. Utilize an ARPA-like organization that is flat, nimble, and sparse, yet capable of setting goals and making decisions that will allow it to sustain for long periods of time those projects whose promise is real, and to cull out programs that do not prove to be productive or as promising as anticipated.

4. Create a new tool to bridge the troubling gaps between basic energy research, development, and industrial innovation. It can serve as a model for improving technology transfer in other areas that are essential to our future prosperity.

The Gathering Storm committee did not believe it should specify the organization and mission of ARPA-E in great detail. We believed that should be worked out by the Secretary of Energy and the Under Secretary for Science in rapid, but intense, consultation with experts from the scientific, engineering, and entrepreneurial communities.

In the 1950s, defense visionaries realized that the military had to reach out to new communities for the innovative technologies to counter the rapidly changing threats of the post Sputnik era. They established the original ARPA in the Department of Defense. It was enormously successful and paid great dividends to both our military and civil societies. We believed that ARPA provides the right framework on which to design ARPA-E. It is a proven model.

Capitalizing on the Vision

The 2007 *America COMPETES Act* incorporated the Academies recommendation for creation of ARPA-E and authorized its establishment. In 2009 the *American Recovery and Reinvestment Act* (ARRA) provided $400 million for ARPA-E, the formation of which President Obama announced in a speech at the Annual Meeting of the National Academy of Sciences on April 27, 2009.

Last week, Secretary Chu reflected on these efforts before the Senate Energy and Natural Resources Committee. In particular, he indicated that

> "changing the way we do business at the DOE to improve customer responsiveness and the quality of our selection of competitive grants. As an example, in order to identify the best possible reviewers for the first round of ARPA-E proposals, I wrote a letter to many of the Presidents of our research universities to ask for the names of their best scientists and engineers. We then called upon those people to help review the proposals, arguing that they should help us as part of their patriotic duty. The technical community responded heroically and we were able to review 3,700 applications, conducting over 4.2 person years of work, in a few short weeks. That fact that we could only fund 1 percent of the applications speaks volumes that additional research support would be money well spent."

Secretary Chu's characterization of the early stages of ARPA-E is certainly consistent with the Academies conceptual ideas reflected in the Gathering Storm report.

Meeting the Challenges and Preserving the Vision

The design of the initial program solicitation by ARPA-E is quite consistent with the kind of program envisioned in the Gathering Storm report. Although the Academies has not formally evaluated them, the first round of awards seems consistent with fundamental objective of exploring innovative and potentially transformative technologies that are unlikely to find traditional support. For example, a liquid metal battery that show promise for providing grid-scale electrical energy storage, a new wind turbine that can achieve higher efficiencies with a smaller size, and a new approach to carbon capture inspired by a human body enzyme are all examples from this first round of awards.

Looking forward, it is essential that ARPA-E remain faithful to the original goals of pursuing high-risk, high-payoff opportunities, staying connected and current with the vibrant community capable of carrying out ARPA-E activities, and re-tuning the portfolio of activities continuously to quickly initiate and sustain new activities and to rapidly phase out those that show less promise just as quickly. Otherwise the ARPA-E mission will merge into the balance of the energy R&D mission, re-introducing the gap ARPA-E was designed to fill.

Critics of the original conceptual ARPA-E design raised a variety of issues, including that an ARPA-E might not address the actual barriers to new energy technology; that it is based on a research agency model that does not apply well to energy; that different proponents of ARPA-E describe different missions for it; that it would compete with, or get swallowed up by existing energy research programs; and that it is unclear how it

would be distinct from other energy research programs. At this point in the agency's evolution, I would characterize these criticisms as potential risks, but ones that will be avoided if the new agency keeps on its current path, true to its mission, and attracts talented managers.

Perhaps a more recent challenge, not unrelated to the challenge of preservation of the ARPA-E's distinct mission, is coordination of the agency's efforts with other DOE approaches for building strong channels of innovation, such as the Energy Frontier Research Centers, which are multi-year, multi-investigator scientific collaborations focused on overcoming known hurdles in basic science and, Energy Innovation Hubs, which will establish larger, highly integrated teams working to solve identified high-priority technology challenges. I believe that with careful management and clear goals, these elements can form a productive and efficient ecosystem for energy innovation and technology deployment.

Energy is absolutely fundamental to a modern economy, but the historical patterns of energy supply and utilization in America are on the verge of changing substantially. Exactly how our energy use should or will change, and at what rate, is a very difficult and complex challenges for this generation. For over three decades America's capacity for technology innovation has been a cornerstone of our national strategies for dealing with both current and long-term energy policy issues, but the new sense of urgency has raised the stakes and the scale of the challenge. The early stages of development of ARPA-E show promise as a key component in nation's energy R&D portfolio that has been missing for many decades.

Thank you again for the opportunity to share my thoughts with you today and I look forward to addressing any questions the Committee might have.

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Charles M. VEST

Charles M. Vest is president of the U.S. National Academy of Engineering and president emeritus of the Massachusetts Institute of Technology. A professor of mechanical engineering at MIT and formerly at the University of Michigan, he served on the U.S. President's Council of Advisors on Science and Technology from 1994-2008, and chaired the President's Committee on the Redesign of the Space Station and the Secretary of Energy's Task force on the Future of Science at DOE. He was a member of the Commission on the Intelligence Capabilities of the United States Regarding Weapons of Mass Destruction and the Secretary of Education's Commission on the Future of Higher Education. He was vice chair of the U.S. Council on Competitiveness for seven years, has served on the boards of DuPont and IBM, and was awarded the 2006 National Medal of Technology. He holds ten honorary doctorates and received the 2006 National Medal of Technology.