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Chairman Boehlert, Mr. Gordon, thank you for the opportunity to testify before your committee this morning.

Mr. Chairman, rising energy demand, constrained supplies, high and volatile energy prices, the geopolitical entanglements associated with the concentration of energy resources, and suggestions of sooner-than-anticipated impacts of global climate change, test the resilience of our economy and our scientific and engineering preparedness. They also test our policy choices, including the investment of scarce federal research dollars.

These and other pressing energy issues suggest that we have a relatively short time frame to initiate fundamental changes in how we produce, distribute and consume energy. Not only do we need to develop new technologies to provide sustainable energy supplies but the lead times for infrastructure investment and construction and capital stock turnover are daunting.

One of the most significant challenges facing energy policymakers is how to calibrate our energy policy responses and investments to overcome these time constraints, and to do so in ways that minimize price volatility, environmental impacts, global geopolitical tensions, and the stranding of industry assets.

The "ARPA-E" proposal constitutes a welcome effort to respond to these and other critical energy needs by accelerating research in game-changing technologies. I applaud the National Academy for its success in bringing this issue into focus in its recent report "*Rising Above the Gathering Storm"*, Congressman Gordon for introducing legislation in support of ARPA-E, and Chairman Boehlert and the Committee for this hearing today which provides us with an opportunity to discuss how an ARPA-E and its possible refinements might advance key energy policy objectives.

DOE's programs, researchers and laboratories conduct high quality and important work on behalf of the nation. DOE's applied research programs were deemed fundamentally "worth it" in a previous and relatively recent National Research Council report. Implicit in the NAS Committee recommendation for an ARPA-E, however, is the need for a new way to conduct a portion of the nation's energy research business at the Department of Energy. This should not be read as an indictment of DOE's energy research programs. Rather it represents an attempt to effectively address serious and gathering energy needs in a compressed time frame – an additional tool for accelerating the transformation of the energy marketplace.

Before a discussion of some general concerns with the specifics of ARPA-E, it is instructive to review some of the desirable features of DARPA that are highlighted in the NAS report (presumably for replication):

- A small, relatively non-hierarchical organization
- Flexible hiring and contracting practices that are atypical of the federal government
- The ability to hire quickly from the academic world and industry at wages substantially higher than those of the federal workforce
- Short tenures, turnover of personnel enabling fresh leadership and ideas on a continuous basis

It is noteworthy that these attributes focus primarily on *process* -- relative freedom from the restrictions and requirements under which most federal research programs operate including

burdensome contracting, reporting, and oversight orders and regulations, low pay grades, the rigidities of the civil service system, and multi-leveled management hierarchies.

Other *structural or research model* features of a DARPA that are highlighted as desirable for translation into an ARPA-E include:

- A lean, effective, agile – and largely independent – organization that can stop and start targeted programs based on performance and …relevance
- Creative, out of the box transformational research that could lead to new ways of fueling the nation . . . as opposed to incremental research on ideas that have already been developed
- Longer-term research funding in a highly flexible program – risk taking

While not specifically highlighted in the NAS report, some additional desirable features of DARPA (included in presentations by Dr. Richard Van Atta, formerly with DARPA) are:

- Development of integrated concepts beyond the purview of a single service
- Taking on large-scale proof of concept demos with a scientific process and a willingness to fail
- Working with the OSD leadership to broker the commitment of the services

Given these attributes and features, the NAS recommendation of the DARPA model as a starting point makes sense. There are however some fundamental differences between the DOD and DOE cultures, bureaucracies and customers that necessitate significant calibration of the DARPA model for an ARPA-E like program to be successful at DOE. We have been asked to respond to a set of questions about the ARPA-E approach. I will briefly discuss certain issues raised by ARPA-E as proposed by NAS then address the questions you have asked me by offering some thoughts on possible refinements of the ARPA-E concept.

General concerns with ARPA-E as described in the NAS report fall into the following areas:

- Program objectives
- Organization/reporting
- Customer base
- Funding/matching funds

Objectives of ARPA-E. It is unclear from the NAS report precisely what type of research outcomes and objectives the Academy contemplates for an ARPA-E. The report indicates that ARPA-E should fund and manage "transformational" and high-risk, high-payoff research, which is defined earlier in the report as a "subset of basic research." The report, in discussing the need for ARPA-E says that, "In particular, ARPA-E could invest in a broad portfolio of foundational research …" This objective is not easy to distinguish from that of DOE's Office of Science; this office is already funded at around $3.6 billion per year and has received a half-billion dollar plus-up in the President's FY07 budget request.

The NAS report also describes ARPA-E's benefits to include "[accelerating] innovation in energy and the environment for both traditional and alternative energy sources and in energy efficiency mechanisms." Further, the report's description of ARPA-E identifies very specific research structures and technologies, indicating that one of ARPA-E's benefits would be "[fostering] consortia of industry, academe, and laboratories to work on critical research problems, such as the development of fuel cells." These program benefits and targets suggest an applied research program and appear to conflict with the definition of basic research which eschews timeframes, specific applications and products and focuses instead on "gaining knowledge or understanding of the fundamental aspects of phenomena."

These descriptions beg several questions. Is ARPA-E primarily a basic research program, an applied research program, a program to "turn cutting edge science and engineering into

technology", an effort to accelerate commercialization, or all of the above? Each of these suggests different leadership, organizational structures, personnel capabilities, and reporting chains, as does a single program that contemplates performing *all* these functions (an approximation of DARPA). A clarification of program objectives will drive the research management model and is fundamental to program success. Further, there needs to be a clear delineation between DOE's existing basic and/or applied research programs and ARPA-E's mission, research targets, reporting chain, etc.

ARPA-E Organization/Reporting. The NAS recommends that the ARPA-E program director report to the Undersecretary of Science. The ARPA-E proposal represents a fairly significant departure from how DOE currently conducts business. It is bound to raise issues of coordination with existing programs, concerns about picking winners, and other potential oversight issues as the program breaks new and controversial ground.

These are sensitive issues both internally and externally and may require the imprimatur of the Secretary or Deputy Secretary whose portfolios are the broadest and authorities are sufficient to manage and mediate the controversies that could arise from such a fundamental change in approach to DOE research management. Also, the unique contractual, personnel and pay scales contemplated in an ARPA-E program may require greater organizational separation from existing programs (organizational independence is identified as a key positive feature of DARPA) than is possible in a reporting structure through the Undersecretary with line authority for other programs.

ARPA-E Customer Base. The nature of the customer base serves as a key point of departure from a pure ARPA-E replication of DARPA and what might actually work at DOE; this difference is not trivial and should inform this discussion and its outcomes.

DARPA funds a large network of researchers outside of the Defense Department; these are, however, DARPA-funded "performers" as distinguished from its "customers." DARPA's sole customer and the focus of its mission – "*to maintain the technological superiority of the U.S. military and prevent technological surprise from harming our national security by sponsoring revolutionary, high-payoff research that bridges the gap between fundamental discoveries and their military use*" – is the military. As such, the peril of "picking winners" by DARPA is very manageable as there is only one customer valuing the results.

This is contrasted with the ultimate customers for the products of DOE's applied energy research programs -- literally thousands of players in a single energy sector, multiplied by the many different sectors that comprise our energy industry. Further, most of these customers are private industry stakeholders for whom the value of research is measured in the price and availability of a commodity. This places high value on short term results. Also, picking winners and losers could affect both the value of that commodity and the relative worth of the research beneficiaries; cost and price are critical measures of success. Finally, picking winners threatens to strand existing industry assets. As such, the peril to bureaucrats, researchers and program funding is significant and much more subject to external political pressures; picking winners, as a matter of DOE policy, is often actively discouraged or resisted.

Funding Mechanism/Cost Share. The NAS report recommends funding levels of $1 billion a year for ARPA-E after an initial ramp-up period, a level deemed necessary for program optimization and success. Needless to say, finding new money at this level will be difficult and there will be a temptation to carve out funds for ARPA-E from existing programs, most likely at levels that are substantially lower than those recommended in the Academy report.

There are two risks to this approach: 1) seeking funds from existing programs will likely intensify internal DOE program resistance to ARPA-E and could jeopardize the establishment of the program, and; 2) an ARPA-E program, by virtue of its new and unique approach to research management at DOE, will be controversial. Inadequate funding levels,

through either appropriations or a re-programming of funds from existing programs, could help ensure program failure, confirming the prognostications of program skeptics.

It is worth noting that at DOE an ARPA-E that is focused primarily on applied R&D (or includes a substantial applied R&D component) would typically require industry cost share (which is not the case at DARPA). Federal procurement, intellectual property, contract management provisions, DOE orders and other federal requirements are off-putting to many industry players, placing de facto barriers to industry participation and cost share commitments – essential elements to successful applied energy R&D, including demonstration, deployment and technology transfer.

Federal energy R&D is performed under the constraints of annual appropriations which are inconsistent from year-to-year, administration-to-administration and secretary-to-secretary. Also, program funds are largely "mortgaged" from the start, and increasingly line-itemed. The risks and limitations of the funding process further discourages industry participation and its commitment of matching funds, making it more difficult to optimize the migration of technologies into the marketplace. If ARPA-E is funded at relatively low levels in its early years, the ramp-up in the out years as contemplated in the NAS report would place that important increment (likely necessary when projects get to the demonstration phase, for example) in competition with other DOE programs as well as with programs in other agencies that are funded through the Energy and Water Appropriations Committee; this lack of certainty in out-year funding could further complicate and discourage longer-term industry commitments to critical projects.

Making ARPA-E Work. The following are some thoughts and recommendations (strictly my own, there are many alternatives and options) on how an ARPA-E might accommodate some of the idiosyncrasies of the DOE culture, structure and customer base that could maximize program effectiveness and address some of the concerns articulated in the Committee's questions.

Role of ARPA-E at DOE. There are many high level policy objectives that could serve as the basis for ARPA-E research investments, given the broad range of energy needs facing the nation. I would recommend four areas that could provide focus as well as an organizing function, although ARPA-E program managers should be given wide latitude in addressing these challenges including the freedom to deviate from core focus areas if warranted. Also, these focus areas do not approximate the "strategic thrusts" of DARPA, which for a new ARPA-E would have to be identified after significant analysis and discussion. General focus areas for ARPA-E, however, should include:

- development of economically sustainable energy sources, which implies a reduction in oil consumption and US reliance on imported energy from unstable regions of the world, and the development of domestic, hemispheric and alternative energy sources
- environmental mitigation, particularly greenhouse gas capture and sequestration,
- energy infrastructure development to produce, refine and distribute new sources of energy
- energy efficiency, with a focus on end use efficiencies

To a large extent, these focus areas duplicate those of existing DOE programs, which have developed numerous high-impact technologies, and have enhanced the nation's knowledge base in critical areas. There are however, some gaps inherent in the structure of DOE programs:

- DOE's applied research programs are organized around fuel sources, e.g., coal, oil, gas, nuclear, renewables (the efficiency program is an exception). The existing organizational structure and focus provides a solid foundation for the Department's applied research and the support of strong constituencies; it runs the risk however of isolating oil supply from transportation or fossil fuels from efficiency, for example,

and promotes a tendency to focus on incremental or discrete technologies (exceptions are generally *within* programs, not *across* programs) as opposed to systems that integrate research needs from supply to distribution to end use.
- The organizational separation of DOE's basic energy research program from its applied research programs makes sense in many instances, but it also makes the migration of certain basic research *findings* to applied research *solutions* undisciplined, more difficult, and often, serendipitous.

There are both ad hoc and, in some instances, formal structures at DOE that encourage communication and coordination between the various applied research programs and between the applied research and basic research programs. In the final analysis, however, the competition for funding from the same appropriation, bureaucratic separation, and different program cultures and performance measures, ultimately work against optimum levels of cooperation and coordination across programs.

An ARPA-E like program could help fill these gaps and supplement but not supplant the missions of existing DOE programs. As noted earlier, the "development of integrated concepts beyond the purview of single service [program]", is one of the features of DARPA that is desirable for replication. To some extent, on certain key problems to be identified, an ARPA-E could provide the *formal integrating function* that fosters a portfolio approach to a problem. In addition, providing ARPA-E with *administrative flexibility* in contracting, hiring, etc., and the easy transfer of personnel and ideas between the government, industry and academia will further distinguish ARPA-E from existing DOE programs.

Finally, replicating DARPA's formal *extraction of value from the entire research continuum* -- from basic to applied to development to deployment -- would be largely unique to the DOE system (DARPA's budget reflects the research continuum including basic and applied to large scale demonstration). Directing a minimum percentage of program funds to basic research -- for both the national laboratories and universities -- would protect against the tendency of DOE's energy R&D customer base comprised largely of industry to focus on near term research and results. Congress might also consider setting aside a portion of ARPA's funds as venture capital for promising, innovative opportunities in the private sector.

In short, ARPA-E would be distinguished from existing DOE programs more by its structure than by the policy objectives its research would address. There is, however, a danger in a "structural" as opposed to policy-driver distinction; without an upfront, clear articulation of some fundamental strategic research thrusts, an ARPA-E could risk becoming an organization in search of a mission. Nevertheless, the drivers described above do not differ substantially from similar gaps DARPA seeks to fill – "research that the services are unlikely to support because it is risky, does not fit [the services] specific roles or missions, or challenges their existing systems or operational concepts."

ARPA-E Reporting Structure. From an organizational/reporting perspective, it is essential to program success that the ARPA-E program director be a direct report to either the Secretary or Deputy Secretary for the reasons articulated earlier in this discussion. This would be especially important in the start-up years of the program to help maximize opportunities for success and tracks the development of DARPA, which also reported to the Secretary and Deputy Secretary in its early years.

The size and nature of the program also raises the issue of whether or not the program director should be Senate-confirmed. ARPA-E would be both controversial and engaged in high-risk, high-payoff research, which suggests, at times, high-profile failures. Also, depending on the final shape of ARPA-E, the program director will require a very unique skills set, likely to include a combination of research, government and industry experience. Selection of the best individual as program director is critical, as is continuity in that position. This should not be considered a political job; insulating the director's position from the confirmation and/or political appointment process is desirable, as would be assistance in

the search for the right individual with the right credentials from, for example, a subcommittee of the Secretary of Energy's Advisory Board (SEAB).

DOE Customer Base. Accommodating the differences between the DARPA and DOE customer bases is one of the biggest challenges for an effective ARPA-E. Ideally, an ARPA-E would aggregate these key players in the research value chain: (1) technology investors who fund research at all stages of technology development; (2) technology developers who conduct basic and applied research; (3) entrepreneurs who provide ideas and expertise to technology deployers; and (4) technology deployers who are the purchasers of technology and use advanced technologies for energy production, distribution and end use. A formal advisory committee structure that includes representatives from each of these stakeholder groups could provide important strategic direction and real-world input, but care would need to be taken to ensure that this does not limit the flexibility of program managers. Accommodating the views and interests of these key players in the research value chain would also maximize opportunities for successful technology transfer and diffusion in the energy marketplace.

Research management and research performing consortia provide additional avenues for accommodating the interests of diverse and numerous industry customers as well as for mitigating concerns about picking winners. An example of this approach is seen in the Ultra-deepwater and Unconventional Natural Gas Supply R&D program included in EPACT last year. Like ARPA-E, this program provides an additional tool for managing DOE research. While directing substantial oversight by the Department, including strict conflict of interest provisions, it requires that the program be managed by a competitively selected research management consortium that includes industry, academia, national laboratories, venture capital firms, service companies, private research institutions and large end users representing all sectors on the gas supply value chain. The consortium is not a research *performer*; rather, with the approval of DOE, it establishes the research agenda, develops project specifications, selects and manages research projects, and transfers the technology into the marketplace. The program also includes a complementary research program element at the National Energy Technology Laboratory.

Funding ARPA-E. If ARPA-E is designed to fill the gaps in the current DOE structure as an agile "integrator" that extracts value from the entire research value chain -- as well as a high-risk, high-payoff and long term research manager -- it needs to be insulated from external pressures and the natural resistance of existing DOE programs to the maximum extent practicable. In this regard two things are worth noting: the NAS report indicates that in the beginning DARPA was "threatening" to the DOD research establishment; and high risk research projects are bound to have a relatively high failure rate. As such, at a minimum, ARPA-E should be a Congressionally-endorsed program funded with new money, at the full one billion dollar level. It should, however, be given the flexibility of "no year" money in order to ramp up in the early years and accrue funds for the more expensive out years.

Funds for new program are however extremely tight. As such, the Congress should also consider other options to pay for ARPA-E. The Natural Gas Supply Research Program described above is funded through a Trust Fund at Treasury and receives mandatory funding from federal oil and gas royalties. The Energy Information Administration analyzing an earlier version of this program indicated that it would result in increased domestic gas supplies and attributed its probable success to the funding certainty of the Trust Fund. There is an attractive policy synergy in utilizing oil and gas royalties to develop sustainable energy sources; the royalty stream would, however, have to be sufficiently robust over time to help fund this transition.

Another option the Congress might consider is the mechanism used to fund DOE's Clean Coal program, which received it entire multi-year funding in a single year and from which it has been drawing down over time as projects are approved and implemented. This does not address concerns over the funding of new starts. It would however address key issues with

respect to maintaining industry support and cost share by demonstrating that the government would be a reliable partner over a long period of time.

Finally, the Congress might consider the results of a recent poll that indicated the American public would support an increase in the gasoline tax *if* the funds generated from the tax were directed to reducing our oil reliance and addressing climate change. To ensure the public that these funds were being wisely spent, the funds would need to be segregated into an innovative and cross-cutting program like an ARPA-E. A one cent per gallon gasoline tax would pay for the entire ARPA-E program at levels recommended in the NAS report

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Mr. Chairman, generating sufficient energy to power the world in ways that protect the environment and promote global economic growth is one of the most significant imperatives of our time. To meet this challenge, we should be prepared to commit significant resources, consider all options, and empower the innovators.

There are significant issues that must be addressed and refinements that would have to be made to make ARPA-E succeed in the DOE culture and bureaucracy. If properly organized, empowered, and funded, however, an ARPA-E type program could provide a new and aggressive link between the needs of the energy marketplace and research directions, operating as a primary interface between the energy industry and DOE's national laboratories and experts in academia.

Thank you for this opportunity and I look forward to the Committee's questions.