ACTION B-5: Use DARPA As a Model for Energy Research

The federal government should create a DARPA-like organization within the Department of Energy called the Advanced Research Projects Agency-Energy (ARPA-E) that reports to the under secretary for science and is charged with sponsoring specific R&D programs to meet the nation's long-term energy challenges.[41]

Perhaps no experiment in the conduct of research and engineering has been more successful in recent decades than the Defense Advanced Research Projects Agency model. The new agency proposed herein is patterned after that model and would sponsor creative, out-of-the-box, transformational, generic energy research in those areas where industry by itself cannot or will not undertake such sponsorship, where risks and potential payoffs are high, and where success could provide dramatic benefits for the nation. ARPA-E would accelerate the process by which research is transformed to address economic, environmental, and security issues. It would be designed as a lean, effective, and agile—but largely independent—organization that can start and stop targeted programs based on performance and ultimate relevance. ARPA-E would focus on specific energy issues, but its work (like that of DARPA or NIH) would have significant spinoff benefits to national, state, and local government; to industry; and for the education of the next generation of researchers. The nature of energy research makes it particularly relevant to producing many spin off benefits to the broad fields of engineering, the physical sciences, and mathematics, fields identified in this review as warranting special attention. Existing programs with similar goals should be examined to ensure that the nation is optimizing its investments in this area. Funding for ARPA-E would begin at $300 million for the initial year and increase to $1 billion over 5 years, at which point the program's effectiveness would be reevaluated. The committee picked this level of funding the basis of on its review of the budget history of other new research activities and the importance of the task at hand.

The United States faces a variety of energy challenges that affect our economy, our security, and our environment (see Box 6-4). Fundamentally, those challenges involve science and technology. Today, scientists and engineers are already working on ideas that could make solar and wind power economical; develop more efficient fuel cells; exploit energy from tar sands, oil shale, and gas hydrates; minimize the environmental consequences of fossil-fuel use; find safe, affordable ways to dispose of nuclear waste; devise workable methods to generate power from fusion; improve our aging energy-distribution infrastructure; and devise safe methods for hydrogen storage.[42]

ARPA-E would provide an opportunity for creative "out-of-the box" transformational research that could lead to new ways of fueling the nation and its economy, as opposed to incremental research on ideas that have already been developed. One expert explains, "The supply [of fossil-fuel sources] is adequate now and this gives us time to develop alternatives, but the scale of research in physics, chemistry, biology and engineering will need to be stepped up, because it will take sustained effort to solve the problem of long-term global energy security."[43]

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[41] One committee member, Lee Raymond, shares the alternative point of view on this recommendation as summarized in Box 6-3.
[42] M. S. Dresselhaus and I. L. Thomas. Alternative energy technologies. *Nature* 414(2001):332-337.
[43] Ibid.

Although there are those who believe an organization like ARPA-E is not needed (Box 6-3), the committee concludes that it would play an important role in resolving the nation's energy challenges; in advancing research in engineering, the physical sciences, and mathematics; and in developing the next generation of researchers. A recent report of the Secretary of Energy Advisory Board's Task Force on the Future of Science Programs at the Department of Energy notes, "America can meet its energy needs only if we make a strong and sustained investment in research in physical science, engineering, and applicable areas of life science, and if we translate advancing scientific knowledge into practice. The current mix of energy sources is not sustainable in the long run."[44] Solutions will require coordinated efforts among industrial, academic, and government laboratories. Although industry owns most of the energy infrastructure and is actively developing new technologies in many fields, national economic and security concerns dictate that the government stimulate research to meet national needs. These needs include neutralizing the provision of energy as a major driver of national security concerns. ARPA-E would invest in a broad portfolio of foundational research that is needed to invent transforming technologies that in the past were often supplied by our great industrial laboratories (see Box 6-5). Funding of research underpinning the provision of new energy sources is made particularly complex by the high cost, high risk and long-term character of such work—all of which make it less suited to university or industry funding.

Among its many missions, DoE promotes the energy security of the United States, but some of the department's largest national laboratories were established in wartime and given clearly defense-oriented missions, primarily to develop nuclear weapons. Those weapons laboratories, and some of the government's other large science laboratories, represent significant national investments in personnel, shared facilities, and knowledge. At the end of the Cold War, the nation's defense needs shifted and urgent new agendas became clear—development of clean sources of energy, new forms of transportation, the provision of homeland security, technology to speed environmental remediation, and technology for commercial application. Numerous proposals over recent years have laid the foundation for more extensive redeployment of national laboratory talent toward basic and applied research in areas of national priority.[45]

Introducing a small, agile, DARPA-like organization could improve DoE's pursuit of R&D much as DARPA did for the Department of Defense. Initially, DARPA was viewed as "threatening" by much of the department's established research organization; however, over the years it has been widely accepted as successfully filling a very important role. ARPA-E would identify and support the science and technology critical to our nation's energy infrastructure. It also could offer several important national benefits:

- Promote research in the physical sciences, engineering, and mathematics.
- Create a stream of human capital to bring innovative approaches to areas of national strategic importance.
- Turn cutting-edge science and engineering into technology for energy and environmental applications.

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[44] Secretary of Energy's Advisory Board, Task Force on the Future of Science Programs at the Department of Energy. Critical Choices: Science, Energy and Security. Final Report. Washington, DC: U.S. Department of Energy, Oct. 13, 2003, p. 5.

[45] Galvin Panel report, *Task Force on Alternative Futures for the Department of Energy National Laboratories,* Secretary of Energy Advisory Board. Washington, DC.: U.S. Department of Energy, Feb. 1995; PCAST, *Federal Energy Research and Development for the Challenges of the Twenty-First Century*, Report of the Energy Research and Development Panel, the President's Committee of Advisors on Science and Technology, Washington, DC, Nov. 1997; Government Accounting Office. *Best Practices: Elements Critical to Successfully Reducing Unneeded RDT&E Infrastructure.* USGAO Report to Congressional Requesters. Washington, DC: GAO (?), Jan. 8 1998.

- Accelerate innovation in both traditional and alternative energy sources and in energy-efficiency mechanisms.
- Foster consortia of companies, colleges and universities, and laboratories to work on critical research problems, such as the development of fuel cells.

The agency's basic administrative structure and goals would mirror those of DARPA, but there would be some important differences. DARPA exists mainly to provide a long-term "break-through" perspective for the armed forces. DoE already has some mechanisms for long-term research, but it sometimes lacks the mechanisms for transforming the results into technology that meets the government's needs. DARPA also helps develop technology for purchase by the government for military use. By contrast, most energy technology is acquired and deployed in the private sector, although DoE does have specific procurement needs. Like DARPA, ARPA-E would have a very small staff, would perform no R&D itself, would turn over its staff every 3 to 4 years, and would have the same personnel and contracting freedoms now granted to DARPA. Box 6-6 illustrates some energy technologies identified by the National Commission on Energy Policy as areas of research where federal research investment is warranted that is in research areas in which industry is unlikely to invest.