THE HAMILTON PROJECT

DISCUSSION PAPER 2011-05 | MAY 2011

# An Energy Technology Corporation Will Improve the Federal Government's Efforts to Accelerate Energy Innovation

John M. Deutch

## MISSION STATEMENT

The Hamilton Project seeks to advance America's promise of opportunity, prosperity, and growth. The Project's economic strategy reflects a judgment that long-term prosperity is best achieved by fostering economic growth and broad participation in that growth, by enhancing individual economic security, and by embracing a role for effective government in making needed public investments. We believe that today's increasingly competitive global economy requires public policy ideas commensurate with the challenges of the 21st Century. Our strategy calls for combining increased public investments in key growth-enhancing areas, a secure social safety net, and fiscal discipline. In that framework, the Project puts forward innovative proposals from leading economic thinkers — based on credible evidence and experience, not ideology or doctrine to introduce new and effective policy options into the national debate.

The Project is named after Alexander Hamilton, the nation's first treasury secretary, who laid the foundation for the modern American economy. Consistent with the guiding principles of the Project, Hamilton stood for sound fiscal policy, believed that broad-based opportunity for advancement would drive American economic growth, and recognized that "prudent aids and encouragements on the part of government" are necessary to enhance and guide market forces.

THE HAMILTON PROJECT

THE HAMILTON PROJECT

# An Energy Technology Corporation Will Improve the Federal Government's Efforts to Accelerate Energy Innovation

John M. Deutch
*Massachusetts Institute of Technology*

MAY 2011

NOTE: This discussion paper is a proposal from the author. As emphasized in The Hamilton Project's original strategy paper, the Project was designed in part to provide a forum for leading thinkers across the nation to put forward innovative and potentially important economic policy ideas that share the Project's broad goals of promoting economic growth, broad-based participation in growth, and economic security. The authors are invited to express their own ideas in discussion papers, whether or not the Project's staff or advisory council agrees with the specific proposals. This discussion paper is offered in that spirit.

BROOKINGS

# Abstract

Energy innovation is critical to solving many of the energy and environmental challenges we face today, from reducing the risks of climate change to lowering the costs of alternative energy sources. While there is no shortage of ideas that could be a part of our energy future, a major obstacle stands in the way of implementation: proving that these good ideas actually work and are, therefore, worth an investment. The private sector underinvests in technology demonstration because of the expense and uncertainties involved; at the same time, previous demonstration programs carried out by the Department of Energy have met with mixed results. This paper proposes a series of best practices for government support of U.S. technology demonstration and a new institution, the Energy Technology Corporation, that would be responsible for managing and selecting technology demonstration projects. A well-designed technology demonstration program carried out by an organization with the appropriate authority, tools, and expertise would go a long way towards accelerating the process of energy innovation.

# Table of Contents

ABSTRACT 2

CHAPTER 1: THE NATURE OF THE PROBLEM 5

CHAPTER 2: THE INNOVATION CHAIN AND NAVIGATING THE “VALLEY OF DEATH” 7

CHAPTER 3: U.S. GOVERNMENT PERFORMANCE ON ENERGY INNOVATION 9

CHAPTER 4: EFFECTIVE TECHNOLOGY DEMONSTRATION 14

CHAPTER 5: THE ENERGY TECHNOLOGY CORPORATION: A NEW MECHANISM FOR SELECTING, MANAGING, AND FUNDING TECHNOLOGY DEMONSTRATIONS 17

CONCLUSION 20

AUTHOR 21

ENDNOTES 22

REFERENCES 23

# Chapter 1: The Nature of the Problem

The patterns of energy use we rely on today to grow our economy and improve our quality of life have a number of drawbacks, including environmental risks of oil spills or nuclear accidents, the health consequences of air pollution, long-term climate change, and dependence on imported oil. There is a widespread belief that the long-term solution to energy problems will be achieved only through technology innovation. Economic arguments justify government support for research and development (R&D), presumably at the expense of other energy subsidies, because the private sector underinvests in R&D due to its inability to capture future benefits.

However, the U.S. government has had mixed success in its efforts to efficiently promote energy innovation, particularly with regards to energy technology demonstration programs. Energy innovation consists of two steps: (1) Create new ideas. (2) Implement them. It is in the second step where the federal system has not functioned up to its potential: the demonstration of new technology options, where the results of R&D are implemented in a prototype example or a pioneer plant in order to illustrate and analyze the practical performance of the new technology. When properly executed, demonstration projects provide and disseminate information on performance and costs that investors require before deploying new technologies.

The relatively large expense of technology demonstration projects compared to R&D and the U.S. government's historical lack of success leads understandably to controversy and skepticism about the value of these projects. Prominent historical examples of failures are nuclear power programs such as the Clinch River Breeder Reactor of the 1970s, and the Synthetic Fuels Corporation (SFC) of the 1980s.

The most serious shortcoming of current government policy supporting demonstration is the absence of clear agreement on the purpose of technology demonstration and on criteria for how demonstration projects should be selected, designed, and managed. There are four other key deficiencies:

1. The adoption of multiple objectives, including deploying renewable energy technologies, increasing jobs, reducing oil imports, reducing carbon emissions, improving international economic competitiveness of green technology companies, and lowering energy costs for consumers. These multiple objectives compete with each other and need to be prioritized to guide program design.

2. The absence in the Department of Energy (DOE) of a transparent sophisticated modeling and simulation capability for assessing energy systems based on engineering data and reliable and consistent economic analysis. Such a capability would permit the comparison of the likely benefits and costs of alternative innovation programs and the evaluation of alternative policies.

3. Excessive involvement of Congress in the scope and content of the DOE program because of differing regional interests. In order to maintain control of the DOE, Congress does not grant the DOE the authorities required to successfully implement its programs. For example, the DOE does not have the authority to attract individuals with private sector experience and the necessary financial and technical skills to design and execute effective programs.

4. No systematic metrics to track the performance of DOE research, development, and demonstration (RD&D) programs.

The absence of a clear purpose often gives the impression that the government believes it is picking technology "winners." Experience suggests, however, there is reason to question whether the DOE is competent to manage such efforts successfully.[1]

The result of the above shortcomings is widespread belief that the government should limit its involvement to supporting basic R&D and setting broad energy policy through taxes and regulation, and should rely on the private sector for technology demonstration.

I argue in this paper that establishing the bounds of a sensible federally supported energy technology demonstration program and a means of efficiently managing and implementing the effort is important for energy innovation in this country. Additional funds for energy R&D and demonstration are welcome provided that, as discussed below, these funds are spent in a cost-effective manner, which requires addressing the shortcomings of current operations. It is relatively easy for the DOE to manage R&D programs well; the more challenging and important problem is to improve the DOE's management of technology demonstration

This paper proposes that the implementation of the technology demonstration program be assigned to a quasi-public Energy Technology Corporation (ETC), to be created. The ETC should have authority and responsibility for managing the selection and execution of technology demonstration projects (Ogden et al.).

The ETC would have the following characteristics:

1. The corporation would be governed by an independent board of directors nominated by the president and confirmed by the Senate.
2. The ETC would receive a one-time appropriation of resources to support an agreed-on number of demonstration projects. Depending on performance, further funding might be extended. The initial commitment should be sufficient to support on the order of $60 billion in projects over a ten-year period, or approximately twenty projects.
3. The corporation would have flexible hiring authority in order to attract individuals with energy sector experience and financial and technical skills.
4. The ETC would have mechanisms for providing project assistance and project contracting according to commercial practice and not government procurement regulations.

Properly executed, other firms will benefit from the information the ETC will produce; the ETC will thus speed the pace of innovation in energy.

Properly executed, other firms will benefit from the information the ETC will produce; the ETC will thus speed the pace of innovation in energy.

# Chapter 2: The Innovation Chain and Navigating the "Valley of Death"

An understanding of how the energy innovation process works is necessary to establish the proper balance between support for R&D and technology demonstration. In simplified form, there are three stages to innovation:[2]

**R&D → Demonstration → Deployment**

The innovation process begins with the scientific process of researching and developing new technologies. In the demonstration stage, new ideas and technologies are implemented in a prototype plant to evaluate performance and cost—information necessary to assess practical or commercial viability of a technology. "Deployment" refers to the commercialization of the new technology.

The conventional justification for government intervention addresses the early stage of R&D—basic and exploratory R&D. *In general, cost increases dramatically as one proceeds through this process*. For this reason, the transition to "demonstration" is referred to as "the valley of death" (red arrow above). The private sector is unwilling to shoulder the high cost of pioneer facilities that have high economic and technical uncertainty without a stable policy environment, for example to add carbon capture and sequestration to coal-fired electricity generation plants.

Successful energy innovation *must* simultaneously consider technical performance, economic cost, and commercial competitiveness, as well as environmental effects. These numerous considerations point to the need for an integrated development effort that combines consideration of these three factors from the beginning of the development. The innovation process is not linear, and there are feedbacks: technical problems encountered in development, engineering, and demonstration can point to fruitful basic R&D opportunities; discoveries made in early-stage R&D can have a direct benefit on improving the performance or reducing the cost of deployed technologies.

Energy innovation is frequently compared to innovation in the space and defense sector where the government is both end-user and exclusive buyer. The comparison is not useful. For space and defense, innovation is *technology driven* with technical performance *pushing* technical change. For energy, the process is *market driven* with cost *pulling* technical change. Thus, the frequently heard plea for a "Manhattan Project" or "Space Program" approach to energy innovation is misplaced. Successful energy innovation must confront the reality of uncertainty about market prices and government policies, as well as technology possibilities. In the case of defense and space, where the government aggressively and intelligently supports R&D for its own use, the spillover to the commercial sector in electronics, the Internet, computation, communications, and materials has been phenomenal. Different important spillovers may come from DOE RD&D programs, but the nature of the innovation process is substantially different in energy than it is in space and defense because of the need to compete with alternative technologies in a (largely) price-based market economy.

## THREE REASONS WHY PUBLIC SUPPORT OF ENERGY INNOVATION IS NEEDED

The first reason is the conventional justification to compensate for underinvestment by private firms that will not undertake the cost of R&D today because the future benefits are uncertain and cannot be appropriated. Basic R&D efforts can produce unexpected but extremely valuable results for a broad community, but cannot produce a product suitable for commercialization. Yet society benefits enormously from the activity, so public support is justified. Note, though, that this justification is inadequate for designing and

> Successful energy innovation *must* simultaneously consider technical performance, economic cost, and commercial competitiveness, as well as environmental effects.

managing RD&D programs. The reason establishes eligibility but gives no indication of the allocation of resources among the many competing candidates. The reason is *input* oriented (it says spend more money) and does not address desirable *output* measures or give any indication of what works best. No metric is indicated for evaluating the success of public programs or assessing the comparative desirability of alternative programs. Indeed, the conventional justification suggests that uncertainty about future benefits makes such evaluation impossible.

The second reason is to provide information that the private sector is unwilling or unable to provide and where such information has public value beyond an individual firm. (Firms can predict the outcome but cannot capture the benefits.) This second reason applies to the first two stages of innovation: At the basic technology level, examples include providing physical and chemical data, interface standards, and safety and environmental information. At the application level, technology demonstration has the purpose of establishing technical performance, cost, and environmental effects for pioneer technology applications, thus providing technology options for private sector investment. But private firms are unwilling to shoulder the burden of pioneer technology projects because market or policy uncertainty clouds the value of the information. Unlike space and defense where the government is the user of new technology, the private sector uses government-sponsored R&D for energy. This means that the innovation efforts of the federal and private sectors must be considered jointly. The demonstration process must facilitate the transition of knowledge from the public to the private sector.

The third reason is to compensate for external costs (or benefits) that the market does not take into account (i.e., market imperfections). Examples are climate change; risks to public health, safety, and the national defense; and public goods that are not part of, or are imperfectly part of, the market system: for example, roads, air traffic control, and education.

These reasons justify a government role in energy demonstration. The government seeks to demonstrate technical performance, cost, and environmental effects of various energy technologies by providing support for pioneer plants, in advance of general acceptance by the private sector that the technologies are commercially viable. Information from technology demonstration projects informs government policy-makers, private sector industry, bankers, and investors about the commercial viability of a new energy system.

Some hold the view that both technology R&D initiatives and carbon pricing policies are necessary in a meaningful climate policy (Stavins 2010). I would state this proposition differently for energy innovation in general: proper pricing policies are necessary and sometimes sufficient, whereas technology demonstration is sometime necessary but never sufficient to induce desirable innovation.

The private sector will not take the initial risk of developing and deploying new technologies for several reasons:

1. Energy policies that internalize externalities are not in place—for example, higher-cost low-carbon technologies such as carbon capture and storage that could make the technology commercially competitive.

2. Technical or cost performance is uncertain—for example, solar photovoltaic.

3. Energy prices and the competitiveness of alternative technologies is uncertain—for example, natural gas availability and cost.

4. The federal or state regulatory regime for making the energy investment is uncertain—for example, the siting of nuclear or coal-fired power plants, or an interstate high-voltage transmission line. The benefit of government action is to open options for more-rapid private sector investment to meet changing conditions than would be the case without it.

The benefit of government action is to open options for more-rapid private sector investment to meet changing conditions than would be the case without it.

# Chapter 3: U.S. Government Performance on Energy Innovation

Unhappily, no one knows how much the U.S. government is spending on energy innovation. In the early stages of the three-stage process, costs are simply the federal outlays to support work done. However, in the later stages, public costs become more varied. In addition to direct outlays, there are indirect mechanisms, such as production tax credits or payments, guaranteed purchase, and loan guarantees; this includes tax expenditures, which are equivalent to outlays. There are regulatory mandates that provide benefits to favored technologies. State governments and the federal government extend significant benefits and impose regulations that contribute to public spending. The result is that it is impossible to give even a rough estimate of the total cost of U.S. direct and indirect energy innovation assistance; to classify the assistance into R&D, demonstration, and deployment; to track this cost over time; or to compare the cost (and its benefits) to outlays of other countries. Sound public policy begins with the attempt to understand costs and benefits on a quantitative basis. Congress should overcome its inclination to hide costs from voters and should instruct the DOE, or perhaps the Office of Management and Budget, to assemble these fundamental cost data.

## FOSTERING R&D

The U.S. infrastructure for innovation is strong. The record of basic R&D is also strong, and it receives a significant fraction of DOE expenditures (about half). U.S. expenditures for energy R&D have increased significantly over the past five years but are roughly one-half the level in real terms of R&D in the late 1970s during the oil crisis.[3]

The innovation infrastructure consists of intellectual property rules, an educated technical workforce, available standards and data, university collaboration, access to risk capital, government policy toward R&D, and research facilities. These are a necessary, though not sufficient, condition for successful innovation. The United States has been a leader in innovation infrastructure and is widely envied by countries that do not have an effective infrastructure.

### *Early-stage R&D*

The DOE's Office of Science is the principal source of federal support for early-stage R&D (basic and exploratory research). The National Science Foundation, the Department of Commerce (through the National Oceanic and Atmospheric Administration), the Department of Agriculture, the Department of Interior (through the U.S. Geologic Survey), and NASA also have important early-stage R&D programs that are only casually coordinated by the Office of Science and Technology Policy and the Office of Management and Budget. The major performers of this R&D are universities, government laboratories (especially the DOE national laboratories), and, to a lesser extent, private industry.

Historically, this activity has been very productive, yielding ideas that have led to many new technology options, materials, biofuels, fuel cells, and photovoltaics. About a decade ago, the DOE began sponsoring workshops of experts to identify research needs in key areas. The practice of having experts suggest productive technology road maps is important for guiding federal R&D and worth emulation by other agencies. It would be valuable to have greater participation in this planning process by industry technical experts who are more knowledgeable than academic experts about energy market trends and opportunities.

Under the leadership of Secretary Steve Chu, the DOE has initiated several efforts to encourage transformational technologies. These are the Energy Frontier Research Centers (forty-six around the country), and Energy Innovation Hubs (for energy-efficient buildings, fuels from sunlight, and modeling and simulation for nuclear reactors). Most importantly, the highly successful Advanced Research Projects Agency–Energy (ARPA-E) program has funded more than 125 competitive proposals for the development of disruptive technologies in such areas as batteries, carbon dioxide capture, grid management, biofuels, and photovoltaics.

### *Later-stage R&D*

The DOE is the principal agency supporting later-stage R&D (development and advanced engineering) for energy efficiency (buildings, industrial applications, and electricity systems) and energy supply (fossil, renewables, and nuclear). See Table 1 for a summary of DOE expenditures in FY2010 and the budget request for FY2012 for energy activities, excluding nuclear weapons and high-energy and nuclear physics.

### *Applied energy R&D*

There are some notable successes—scrubbers, coal-bed methane, thin film PV—but many have been less successful, such as nuclear fuel cycle, batteries, magneto-hydrodynamics, geothermal, ocean thermal electric, and building performance standards. There are various R&D arrangements: contracts with industry, work at the DOE laboratories, and industry consortia such as the Gas Research Institute and the Electric

TABLE 1

## DOE R&D Expenditure by Technology, FY2010 and 2012 ($ millions)

| Technology | 2010 (Appropriation) | 2012 (Request) |
|---|---|---|
| Hydrogen | 170 | 0 |
| Solar | 243 | 457 |
| Wind | 79 | 127 |
| Geothermal | 43 | 102 |
| Water | 49 | 39 |
| Subtotal: Renewables | 584 | 725 |
| Vehicles | 304 | 588 |
| Buildings | 219 | 471 |
| Industrial | 94 | 320 |
| Electricity deliverability | 121 | 193 |
| Subtotal: Efficiency | 738 | 1,572 |
| Coal | 393 | 291 |
| Natural gas | 17 | 0 |
| Oil | 19.5 | 0 |
| Subtotal: Fossil | 430 | 291 |
| Subtotal: Nuclear | 452 | 444 |
| Basic Energy Science | 1,597 | 1,985 |
| Biologic & Environmental Research | 588 | 718 |
| Advanced Science Computing | 383 | 466 |
| Fusion | 418 | 400 |
| Subtotal: Science | 2,986 | 3,569 |
| Grand Total | 5,190 | 6,310 |

Source: DOE 2012.

## It is not true that increased expenditures… necessarily lead to proportionally greater energy technology outcomes. Improved results are more likely to be achieved by changing practices than by increasing resources.

Power Research Institute.[4] The principal support mechanism is R&D contract payments for all or a portion of the cost of the R&D activity. The chronic execution issues have been cost overruns, ownership of intellectual property, cost sharing, and the federal government and DOE contracting and procurement practices that impede flexible and agile technical development. Members of Congress always have had a great interest in choosing particular technologies and projects to fund because of how they affect local interests. It is not true that increased expenditures in this stage of energy development necessarily lead to proportionally greater energy technology outcomes. Improved results are more likely to be achieved by changing practices than by increasing resources.

### SUPPORTING DEMONSTRATION

There have been three periods of significant demonstration activity during the DOE's history. During the first round, in the early 1970s, the DOE supported a number of large nuclear and clean coal demonstration projects through direct subvention of project costs. The nuclear projects were the Clinch River Breeder Reactor Project near Oak Ridge, Tennessee, and a number of commercial reprocessing plants, including those in Barnwell, South Carolina; West Valley, New York; and Morris, Illinois.

Several large-scale synthetic coal plants were built around the United States during this same period: Solvent Refined Coal I (Air Products Wheelabrator-Frye at Newman, Kentucky), Solvent Refined Coal II (Gulf at Morgantown, West Virginia), H-Coal (Ashland Oil at Catlettsburg, Kentucky), Donor Solvent Liquefaction Process (EXXON at Baytown, Texas), and the Great Plains Coal Gasification Project (American Natural Resources, Beulah, North Dakota).

The nuclear plants never operated: the United States abandoned commercial reprocessing and breeder reactors in the mid-1970s because of the risk of proliferation.

None of the coal plants ever operated as intended. While particular contract terms varied, the general pattern was a 50 percent cost share between industry and the government and no special provision for information dissemination. DOE field offices structured the contracts and managed the projects according to customary federal procurement practices. The cost of a barrel of oil-equivalent produced by the coal liquefaction projects was estimated to be in the range of $85 at project completion, at a time when the price of oil was less than $20 and falling. Congress was intensely interested in these projects, and the DOE experienced a good deal of interference in their management.

The second round of demonstration projects began with the establishment of the quasi-independent SFC in 1980 after the passage of the Energy Security Act. The purpose of the SFC was to reduce dependence on imported oil by providing assistance—using indirect financial mechanisms—to projects that produced synthetic gas and liquid fuel from coal, oil sands, and shale. Its mandate went beyond technology demonstration to subsidizing the construction of plants that were to reach a target production level of 500,000 barrels per day by 1987.

The production target was adopted in anticipation of a doubling of oil prices in the near future. At the time of the debate about establishing the SFC, oil prices were about $40 per barrel and seemed to be headed for $80–$100 per barrel. With little relevant experience, engineering estimates were that synfuels would cost about $60 per barrel. Accordingly, there was significant political pressure to demonstrate a domestic synfuels production capability that would act as a "backstop" to the seemingly endless upward movement of imported oil prices. Congress, industry, and a surprising number of informed energy and international security experts argued that the proper way to demonstrate this "backstop" price was to establish a production target: 500,000 barrels per day for the first phase (which would have represented approximately 7 percent of finished motor gasoline consumption in 1987).[5] In fact, as mentioned above, oil prices were in the process of falling by more than half, thereby rendering the enormously expensive SFC undertaking commercially unfeasible.

The initial "first of a kind" or pioneer plants were expected to cost more, which justified a larger subsidy to begin the "learning" process that many believed would result in lower costs. As late as 1982, in the Reagan administration, the DOE estimated that synfuels production in 2000 could be between 474,000 and 3.2 million barrels of oil-equivalent per day.[6] The SFC struggled on, managing a handful of projects, until it was terminated in 1986 (U.S. Congress 1986). All of the projects selected by the SFC were completed but never operated commercially, because the product cost vastly exceeded the prevailing market price.

The primary lesson of the SFC story is that the government should be very cautious in establishing large programs based on the assumption that current estimates of market price will come to pass. "Demonstration" should be carefully defined to avoid adopting either production targets or fanciful buy-down or "learning" ideas that project reduced cost or improved performance independent of real market experience and unexpected political, regulatory, and technical events. The SFC experience would have been more successful, or at least less expensive, if "demonstration" had meant providing information to the private sector on the technical performance, environmental effectiveness, and cost of a synfuels technology, rather than attempting to achieve production targets independent of the prevailing market price for conventional oil and gas. The SFC experience warns against adopting formulaic policies such as renewable portfolio standards, clean energy standards, and arbitrary emission reduction targets that are based on assumptions about future market conditions.

The SFC offers important lessons for today. The SFC showed that indirect incentives—production payments or tax credits, loans or loan guarantees, or guaranteed purchase—could run a project in a manner that was more credible to the private sector than the alternative of direct DOE involvement in the design and payment for the cost of a demonstration plant.[7] Additionally, the quasi-public organization of the SFC had several advantages over a government-run enterprise. The SFC replaced non-germane government procurement rules with commercial practice that was shown to be effective in selecting meritorious projects and negotiating contracts generally seen as being "fair." The SFC had the authority to hire and compensate a small staff with technical and financial expertise greater than could be found in government service, at a level needed to administer the program. Finally, and perhaps most importantly, the SFC was financed by a single congressional action and avoided the annual congressional hearing and budget cycle, which served to insulate the program to some considerable degree from congressional pressure.

In sum, SFC experience underlines two points: First, it is a mistake for the government to adopt deployment targets because of market uncertainty. Second, the government's success in demonstrating new technology options for private investors requires project management based on commercial practice, free from government procurement practices and congressional interference.

The third round of demonstrations came unexpectedly in 2009 as part of the economic stimulus package for the economic recovery. The 2009 American Recovery and Reinvestment Act (ARRA) included significant funds for infrastructure improvements, especially for clean energy. The 2009 ARRA authorized large-scale demonstration projects, as shown in Table 2.[8]

Funds were provided for direct support and for loan guarantees. The ARRA loan guarantees for nuclear power plants were in addition to earlier legislative authority established by the 2005 Energy Act.

TABLE 2

## Recent DOE Demonstration Project Activity ($ billions)

| **2009 ARRA Act**<br>Direct support | |
|---|---|
| Carbon capture & storage | $3.4 |
| Vehicles | $2.85 |
| Grid modernization | $4.5 |
| Efficiency | $12.0 |
| Renewables | $1.64 |
| Environmental clean-up | $6.0 |
| Innovation | $2.0 |
| Total | $30.3 |

| **Loan Guarantee Programs (completed & committed)**<br>Energy Policy Act (2005), Energy Independence & Security Act (2008), AARA (2009) | |
|---|---|
| Sec. 1703 | $10.6 |
| (Nuclear power plants) | ($10.33) |
| Sec. 1705 | $5.8 |
| Clean Energy | |
| ATVM (Adv. Tech. Vehicle Manufacturing | $8.3 |
| Total | $24.7 |

Source: DOE n.d.a; DOE n.d.b; DOE n.d.c.

Emphasis was placed on rapid implementation of these programs because the main purpose was to stimulate the economy. This, of course, created some tension with the purpose of technology demonstration to provide information useful to the private sector. The projects were "hastily" (in this instance a positive attribute) solicited, selected, and administered by the DOE.

The twin goals of stimulus and clean technology demonstration resulted in some curious contradictions in the authorizing legislation. Projects authorized under Section 1703 must "employ new or significantly improved technologies." Projects authorized under Section 1705, in contrast, must satisfy the condition "that there is a reasonable prospect of repayment by [the] borrower of the guaranteed loan," which is almost a condition of commercial viability that would be adopted by a commercial lending institution.

It is too early to know how this impressive burst of energy infrastructure spending will fare. There are reasons to have a guarded expectation. Projects were selected for multiple objectives under the stimulus package: job creation, infrastructure renewal, clean energy, and improving competitiveness. For example, special attention was placed on revitalizing the automobile sector through advanced technology vehicles projects that supported new manufacturing facilities but did not permit reimbursement for R&D costs. The DOE provided $1.5 billion in grants to battery manufacturing based on the belief (but with no supporting analysis as far as I am aware) that manufacturing costs based on today's battery technology could be reduced to a level adequate for hybrid-electric vehicle or full-electric vehicle use. At the same time, several parts of the DOE, including ARPA-E, were saying that advances in battery technology and improvements in battery manufacturing technology were required to realize sufficiently low battery cost.

The stimulus package has expired, of course, but the 2012 DOE budget includes additional technology demonstration features. The department requests include $200 million to support $1 billion–$2 billion in loan guarantees for "promising innovative technologies," an additional $36 billion for nuclear power projects, and $6 million for the Advanced Vehicle Manufacturing Technology Program. There is no indication of a more disciplined process in the DOE to manage these technology demonstrations. My opinion, honed by decades of painful experience, is that government spending on technology demonstrations does not automatically yield value for creating future technology options. A better process is required.

## RD&D PERFORMERS

As mentioned, historical data for all federal and state financial support for energy innovation through RD&D, both direct expenditures and indirect tax expenditures, are not available. However, the DOE has made available a unique breakdown of DOE direct expenditures for R&D and demonstrations for the FY2010 according to performers of this work.[9] The data are presented in Table 3. The interesting but sobering breakout shows that the DOE labs spend about 44 percent of the total, more than double the amount spent by industry. This does not seem to be a pattern consistent with technology commercialization.

TABLE 3

### 2010 DOE Energy RD&D by Performer ($ millions)

| | | | Performers | | | |
|---|---|---|---|---|---|---|
| Program Areas | Academic | Industry | DOE Labs | States | Other | Total |
| Energy Efficiency and Renewable Energy | 129 | 427 | 809 | 120 | 216 | 1,701 |
| Energy Efficiency and Renewable Energy, Recovery Act | 133 | 603 | 144 | 63 | 2,628 | 3,571 |
| Fossil Energy Research and Development | 86 | 381 | 53 | 104 | 1 | 625 |
| Fossil Energy Research and Development, Recovery Act | 8 | 90 | 1 | 5 | | 104 |
| Nuclear Energy | 19 | 163 | 538 | 69 | 1 | 790 |
| Electricity Delivery and Energy Reliability | 12 | 18 | 65 | 18 | 7 | 119 |
| Electricity Delivery and Energy Reliability, Recovery Act | 1 | 523 | 11 | 10 | 50 | 594 |
| Science | 548 | 288 | 3,319 | 228 | 23 | 4,406 |
| Science, Recovery Act | 64 | 30 | 502 | 2 | 0 | 598 |
| Grand total | 999 | 2,522 | 5,442 | 619 | 2,926 | 12,508 |

Source: Office of the Chief Financial Office, DOE. See endnote 9.

Note: "Other" category includes individuals, non-DOE federal labs, not-for-profit, and other.

# Chapter 4: Effective Technology Demonstration

## DEFINING DESERVING TECHNOLOGY DEMONSTRATION PROJECTS

The key characteristic of a worthy technology demonstration project is the identification of one or more reasons that prevent the private sector from making investments in pioneer plants. Reasons might be (1) uncertainty about technical performance and costs, (2) future regulatory or policy constraints, or (3) environmental and national security externalities. A successful project will provide information that removes these uncertainties for a wide range of future investors. Table 4 illustrates the range of projects that might be considered and the uncertainties that motivate each example.

TABLE 4

### Technology Demonstration Candidates

| Candidate Project | Uncertainty |
|---|---|
| Large-scale solar thermal power | (1) |
| Nuclear power plants | (1,2) |
| Smart electricity grids | (1) |
| Carbon sequestration facilities | (2,3) |
| Clean coal, new/retro-fit carbon capture | (2,3) |
| Cellulosic biofuels production | (1,3) |

A technology demonstration project ranges in cost from hundreds of millions of dollars to several billion dollars. Below the lower limit, the capital at risk is sufficiently small for the private sector to bear the risk. The upper limit is determined by the cost of a plant that has sufficient scale to be a credible model for commercialization. For example, pioneer nuclear power plants or coal-generating plants with carbon capture could easily cost $3,000 to $5,000 per kWe capacity, which corresponds to $1.5 billion to $2.5 billion for a 500MWe plant.

The DOE nuclear loan guarantee offers an interesting example of technology demonstration. Utilities and banks are reluctant to take on the massive capital investment of a nuclear plant because of uncertainty about licensing and public acceptance, the imposition of a significant carbon emission charge (that would make nuclear relatively less expensive compared to coal), and, most important, its high capital cost. The rationale of the nuclear loan guarantee program is that public assistance for the first few nuclear plants, through reduced cost of capital due to a federal loan guarantee, will lower the cost of the next plant to the level of coal. Successful demonstration will provide information to all utilities that nuclear power is a practical option. The program only makes sense if the anticipated cost reduction is credible.

The rationale for technology demonstration of a large-scale carbon sequestration project is different. The private sector has little interest in spending money on sequestration until a carbon emission charge is imposed, and the regulatory requirements for storage facilities are not yet known.

Four important conclusions follow from these considerations of the purpose of demonstration projects:

1. Not all energy technologies require a large-scale demonstration project. For some technologies—for example, distributed photovoltaic electricity generation—information may be widely available, required investment levels low, and the necessary supplier infrastructure in place, so that government-sponsored technology demonstration is not needed.

2. Explicit provisions must ensure that technical, economic, and environmental information obtained in the demonstration is disseminated as broadly as possible to potential private sector adopters.[10] The requirement for dissemination of information from a government-sponsored demonstration project is in conflict with the understandable desire of a private sector firm who shares the project cost to retain the intellectual property rights. In my opinion, the mechanism of granting exclusive intellectual property rights to a private company or consortium that has won a competition for a demonstration project by agreeing to the highest cost-sharing does not satisfy the criteria of technology demonstration. This

mechanism amounts to the auctioning by the government of a temporary monopolistic right for the best price, such as the Solvent Refined Coal (SRC) and Exxon Donor Solvent (EDS) coal projects in the 1980s, the FutureGen project in its early form, and the proposed Small Modular Reactor project proposed in the 2012 DOE budget.

3. A sophisticated and transparent modeling and simulation capability based on engineering data and economic analysis should be available to permit analysis and optimization of different system choices and configurations; examples are clean coal generation of electricity and trade-offs between different technologies. This is a different function from the historical data collection and economic analysis performed by the Energy Information Administration (EIA) of the DOE. Accordingly, the function should be assigned to the program offices charged with advancing the technologies.

4. An evaluation system should be put in place based on metrics for the financial, technical, and schedule aspects of each project. Money needs to be spent to analyze the performance of each project and to make this information useful to investors, industry, policy-makers, and the public.

## IDEAL CONDITIONS FOR SUCCESSFUL TECHNOLOGY DEMONSTRATION PROGRAMS

There also are important conditions for realizing a successful technology demonstration *program* from a selected set of *projects*. I list the conditions that are desirable for a successful program and compare some of these conditions with the conditions that have existed in DOE's past demonstration efforts.

1. A stable government energy policy—for example, a known greenhouse gas emissions charge—is needed. In the absence of stable policy, a demonstration program must be pursued either on the basis of existing policy or in anticipation of changed policy. In the latter case, the demonstration project is not commercially viable so government assistance is required. A national energy plan that sets a comprehensive framework also would be welcome.

   Certainty about tax provisions, subsidies, and regulation guide private investment decisions, and signal which technical advances will have and which will not have value in the future. The best example is the effect that the absence of a carbon emissions charge has on investment and technology development in low-carbon electricity generation: nuclear, solar, and coal with carbon capture and sequestration. Absent a carbon charge, there is little incentive for the private sector to make such investments. It might still be sensible for the DOE to finance a technology demonstration that is "out of the money" on a commercial basis, in the absence of a carbon policy, while providing information and realistic options to the private sector if and when the policy changes.

2. Clarity about the purpose of energy policy is also important. It is easy to have a single goal and complicated to have multiple goals, especially when the combination is intended to overwhelm any doubt about the virtue of the policy. Current energy policy seeks to advance several objectives: to encourage the transition from fossil to renewable energy sources, to reduce oil imports, to reduce carbon emissions, to create jobs, to improve U.S. international competitiveness for green technologies, and to lower the costs of energy for the consumer.

   Alternative policy goals will involve trade-offs. For example, a carbon charge will reduce emissions but also lift the cost of electricity for the consumer. Sound public policy requires clarity about the balance struck among the trade-offs resulting from different policy choices.

   Sound public policy also requires a comprehensive multiyear plan that describes how the interrelated energy policies will influence different energy sectors of the economy: transportation, power, industry/commercial, and residential. Such a plan will help guide private sector deployment and technology development investment decisions. Absent a stable plan, how should a utility decide whether to build a low-cost but high-carbon-emitting pulverized coal plant for electricity generation or a high-cost but largely carbon-free nuclear power plant? A disciplined and documented procedure is needed to select the portfolio of technology demonstration projects that are intended to provide options for private sector investment. There should be explicit criteria for selecting the projects—

A disciplined and documented procedure is needed to select the portfolio of technology demonstration projects that are intended to provide options for private sector investment.

for example, prospects for reducing emissions, reducing oil imports, stimulating renewables, creating jobs, and improving competitiveness. To reiterate, a single objective—for example, reducing emissions—is simplest, but multiple objectives are the rule and require explicit weighting in the selection process. I believe the important criteria should be reducing external environmental cost, improving energy security, and lowering the cost of energy for the U.S. consumer. Job creation and competitiveness are broader economic objectives that are not unique to the energy sector.

3. An array of assistance mechanisms should be available to support the demonstration projects: guaranteed purchases, loan guarantees, production tax credits, cost-shared reimbursement. For technology demonstration, indirect mechanisms are preferred over direct support by government contract because they interfere less with the commercial basis on which plants are designed, built, and operated, thus making the results more credible to private investors. A uniform selection process ensures efficient allocation of resources to different demonstration opportunities. But the design of a particular demonstration project depends on its unique characteristics—for example, application, technology readiness, and industry structure. In general, production payments (or tax credits) are preferable to loan guarantees because the former rewards success while the latter insures against the loss of failure.

4. The sponsoring entity must have the technical and financial expertise to formulate a technology demonstration agenda within a specified multiyear budget, manage a fair and open competition among interested performers, and negotiate a contract using commercial standards (not government procurement regulations) that includes provisions for sharing information and intellectual property. This key provision is frequently overlooked in discussion of different organizational arrangements for accomplishing demonstration projects.

5. A distinction must be retained between technology demonstration and technology deployment assistance. Technology demonstration creates technology options for the private sector by providing technical, economic, and environmental information. In contrast, technology deployment subsidizes the cost of deploying technology to compensate for a market imperfection that is seen to disadvantage market entry to the detriment of one of the multiple objectives of energy policy. The deployment assistance can be extended by mandatory regulation (such as renewable portfolio standards for electricity generation, renewable fuel standards for vehicles, Corporate Average Fuel Economy [CAFE] mileage standards, or import restrictions on ethanol), or through tax credits and production payments. In general, deployment assistance applies to an entire technology class and works best when a fixed term is set. Examples of a general deployment assistance provision whose effectiveness has suffered from uncertainty in application are the R&D and the energy investment tax credits.

   Technology demonstration programs should not have production targets. The reason is that many uncertain factors influence whether a *successful* technology demonstration project will lead to commercial deployment: government policy, the price of energy, and the cost and performance of competing technologies. Production targets may be part of a technology deployment program, but government production targets are almost always a bad idea, because they suggest that the government knows or can influence the uncertain factors that influence market outcomes. Of course, in contrast to production targets, it is entirely appropriate to set performance, cost, and schedule milestones for a technology demonstration project. If a project does not meet its milestones, consideration should be given to modification or termination of the effort.

It is interesting how the three different demonstration campaigns stack up with regard to a number of the key desirable demonstration project and program characteristics discussed above. Table 5 presents my judgments. The important message is that none of the efforts has completely met all the desirable characteristics.

TABLE 5

## How Well Did They Do?

| | DOE 1970s | SFC | ARRA 2009 |
|---|---|---|---|
| Explicit policy | Yes | Yes | No |
| Analytic support | No | Some | Some |
| Strong project management | No | Yes | No |
| Indirect assistance | No | Yes | Yes |
| Information dissemination | No | No | No |
| Outside expertise | No | Yes | Some |
| Free of government regulations | No | Yes | No |
| Evaluation/ metrics | No | No | No |

# Chapter 5: The Energy Technology Corporation: A New Mechanism for Selecting, Managing, and Funding Technology Demonstrations

The government needs a disciplined process for planning and executing its technology demonstration program. This paper's primary proposal is the establishment of a quasi-public ETC. The ETC should have authority and responsibility for managing the selection and execution of technology demonstration projects. The ETC is the best way to realize potential benefits and avoid the risks of this type of government activity.

I now briefly expand on the characteristics of the proposed ETC given in Section I:

1. An independent board of directors nominated by the president and confirmed by the Senate would govern the corporation.

   The board would be composed of eight individuals with backgrounds in finance, technology, project management, and environmental protection. The chairperson of the ETC would have executive authority over the management of the enterprise and maintain this position subject to the confidence of the board; all members would have fixed terms of ten years.

2. The ETC would receive a one-time appropriation of resources to support an agreed-on number of demonstration projects. Depending on performance, further funding might be extended. The initial commitment on the order of $60 billion should be adequate to finance approximately twenty projects over a ten-year period.

   The cost of a project to the ETC would be less than the total project cost because the ETC is financing only the difference between the project cost and anticipated market revenues, if any. Assuming a typical level of assistance provided to a project might be $3 billion, gross exposure to the ETC over ten years of the twenty projects would total $60 billion. Failed projects would not necessarily entail a loss to the ETC of the entire exposure. Loan repayments from successful projects, as well as any revenue from cost-sharing agreements, would make funds available for reinvestment in new projects. In practice, budget scoring of these assistance costs is quite different from the total exposure discussed here, but this accounting difference need not trouble us. Continuation of the ETC beyond the ten-year period would depend on the success of the ETC-sponsored projects.

3. The corporation would have flexible hiring authority in order to attract individuals with energy sector experience and financial and technical skills.

   This ETC needs authority to hire individuals outside the professional civil service system for temporary service at commercially competitive salary levels. This is the only way to attract individuals with the necessary skills to design and implement complex demonstration projects. In contrast, the directors and top management of the ETC should accept modest compensation in order to emphasize the public service aspect of the assignment.

The government needs a disciplined process for planning and executing its technology demonstration program…The ETC is the best way to realize potential benefits and avoid the risks of this type of government activity.

4. The mechanisms for providing project assistance and project contracting would be according to commercial practice and not government procurement regulations.

   The procedure that the ETC should follow for each demonstration project has the following steps:

   (a) A broad industry solicitation defining the technical specifications and desired schedule for the project, accompanied by the range of assistance, in terms of mechanisms and amounts, that the ETC might provide.

   (b) Evaluation of submitted bids in terms of technical readiness, cost, and project risk.

   (c) Negotiation of a contract with the selected performer of the project. A critical aspect of the contract is the negotiation of cost sharing and intellectual property ownership. For some demonstration projects—for example, carbon sequestration—no cost sharing and retention of the intellectual property by the ETC, hence by the government, is reasonable. For other projects—for example, first-of-a-kind nuclear power plants—significant cost-sharing and granting of intellectual property to a company seems appropriate.

   (d) Monitoring of the project cost and schedule.

   (e) Evaluating and disseminating of the results of the project.

   The ETC should also have authority to use a broad range of financing mechanisms: guaranteed purchase, loan guarantees, equity participation, and cost reimbursement for nonrecurring engineering. Importantly, the contract should be on commercial terms and should not be required to conform to federal acquisition regulations.

Since the central purpose of technology demonstration is to provide information to the private sector, the ETC-supported projects should include a significant analysis and documentation of their technical and economic performance. This activity should add at most 10 percent to the project cost of the technology demonstration. Such information would also contribute important data for the separate DOE modeling and simulation of energy technologies.

## COMPARISON TO OTHER PROPOSALS FOR MANAGING TECHNOLOGY DEMONSTRATION

The proposed ETC resembles the SFC. The essential difference between the ETC and the SFC is that the ETC is concerned exclusively with demonstrating the technical and economic status of new technologies, whereas the SFC was concerned with achieving production targets without regard to market price. The ETC should adopt the philosophy that influenced the SFC structure—properly conceived at the time—that the DOE and other energy-related government agencies do not have the authority, tools, and competence to execute successful large-scale projects that demonstrate commercial potential to the private sector.

Nevertheless, the resemblance prompts consideration of alternative arrangements. Four main alternatives to DOE management of technology demonstrations have been proposed:

1. **The Clean Energy Deployment Administration (CEDA).** Senator Bingaman, Chairman of the Senate Energy and Natural Resources Committee, has proposed the creation of a semi-independent unit within the DOE to finance and manage technology demonstration projects.[12] The analogy to the Federal Energy Regulatory Commission (FERC) is imperfect because FERC is a regulatory agency and CEDA is involved with project management. Maintaining CEDA within the DOE certainly attracts greater congressional support, because the arrangement retains greater potential for congressional influence. This makes me dubious that the "semi-independent" character of CEDA will be sufficient to achieve the flexibility in personnel and procurement practices and objective selection process that are essential to effective technology demonstration. CEDA also has a broader mission of demonstration and deployment assistance than the narrower (and less expensive) demonstration focus that I advocate for the ETC.

2. **Reliance on DOE-funded industry consortia.** Expand DOE-sponsored industry consortium—for example, the Partnership for a New Generation of Vehicles, the Advanced Battery Consortium, the Electric Power Research Institute, and the Gas Research Institute (now part of the Gas Technology Institute), and the Carbon Sequestration Regional Partnership—beyond R&D to technology demonstration.

3. **A clean energy bank.** This approach provides capital to an entity to support energy technology deployment.[13] This variant basically establishes a quasi-public entity similar to the Export-Import Bank for this purpose. These proposals focus on extending favorable credit terms for deployment rather than on technology demonstration. However, none of the clean energy bank proposals is precise about the criteria that should be applied for project selection and to what extent the criteria would differ from those applied by a commercial bank.

4. **Industry investment boards.** Stanford Professor Paul Romer proposes to turn responsibility over to private sector firms to decide on investments that have the greatest potential for common benefit, financed in part by tax revenue (Romer 1993). R. K. Lester and D. M. Hart have recently proposed a similar Region-based Innovation Authority (Lester and Hart 2011).

Each of these alternatives needs to be judged against the alternative of doing nothing (probably excluded by the desire of Congress to do something) and of relying solely on the DOE (with the expectation of mixed results). The alternatives emphasize differing elements: greater involvement of industry (DOE consortia and Romer), extension of credit on favorable terms (a "green bank" and CEDA), and creation of a technology demonstration option (ETC). It is possible to imagine combining these elements in different ways. There seem to be no interesting or relevant international models for technology demonstration. The OECD and the International Energy Agency use the traditional mechanism of direct government support; China and Japan rely on central government direction.

I prefer the ETC model because of its essential elements: (1) emphasis on creating options through demonstration, not deployment, (2) commercial- rather than government-based project management, (3) involvement of individuals with technical and financial experience in the private sector, and (4) freedom from the congressional authorization and appropriation cycle.

Since the central purpose of technology demonstration is to provide information to the private sector, the ETC-supported projects should include a significant analysis and documentation of their technical and economic performance… Such information would also contribute important data for the separate DOE modeling and simulation of energy technologies.

# Conclusion

The DOE's responsibility for managing energy innovation goes well beyond sponsoring basic research and early technology development, although this is where the government involvement has the greatest theoretical justification and where the DOE's record or performance is strongest. Significant advances in basic energy technologies will come from sustained support of multidisciplinary research efforts at universities, government laboratories, and industrial firms, and not from a magical "technology break through."

Priority should continue to be given to basic R&D, especially through the new mechanisms that have recently been put into place—the Energy Innovation Hubs, the Energy Frontier Research Centers, and ARPA-E—to bring larger, multidisciplinary teams together to address a key subject. There has been a sharp increase in the funds allocated for R&D—the first stage of the innovation process—over the past years, with roughly $6 billion requested in the FY2012 budget. This level should be maintained and perhaps increased over coming years. Combining the management of early-stage R&D (now primarily supported by the Office of Science) and later-stage applied energy R&D (now supported by a separate undersecretary for the applied energy areas) would improve coordination across the innovation process.

The challenge is to understand how the DOE best encourages commercialization of new energy technologies. In fact, energy innovation is constrained not by an absence of new ideas, but by the absence of early examples of successful implementation. The government has a role in technology demonstration because it creates technology options that the private sector is slow to undertake due to the risks involved. The risks go beyond the uncertainty about the technical performance of a new technology to consideration of their cost and public acceptance. The DOE should focus on demonstrating the technical performance, economics, and environmental effects of alternative technologies and thus create options for the private sector.

Government action, whether by regulatory mandate or subsidy that seeks to achieve deployment targets, is inappropriate, because it depends on prediction of future market conditions, especially prices. This approach leads to an extension of endless subsidies on particular technologies that are believed to be "too good to allow to fail."

The past record of DOE management of technology demonstration projects is unsatisfactory. Successful government action on technology demonstration requires sustained application of resources but, more importantly, a willingness to change the conventional approach to implementation. This means creation of an ETC to select and manage demonstration projects. If the government fails to meet this challenge, the consequence will be that the pace at which new energy technology is deployed in the future will be slower than it might be, which in turn means that the economy and the consumer will bear higher costs for energy services than is necessary.

# Author

## John M. Deutch

*Institute Professor, Massachusetts Institute of Technology*

John Deutch is an Institute Professor at the Massachusetts Institute of Technology and serves on The Hamilton Project's advisory council. He has been a member of the MIT faculty since 1970, and has served as Chairman of the Department of Chemistry, Dean of Science, and Provost. Deutch has served in significant government and academic posts throughout his career. In May 1995, he was sworn in as Director of Central Intelligence following a unanimous vote in the Senate, and he served as DCI until December 1996. From March 1994 to May 1995, he served as the Deputy Secretary of Defense. From March 1993 to March 1994, Deutch served as Under Secretary of Defense for Acquisitions and Technology. From 1977 to 1980, he served in a number of positions for the U.S. Department of Energy: as Director of Energy Research, Acting Assistant Secretary for Energy Technology, and Undersecretary of the Department. Mr. Deutch earned a B.A. in history and economics from Amherst College, and both a B.S. in chemical engineering and Ph.D. in physical chemistry from M.I.T.

# Endnotes

1. For example, Cohen and Noll studied six case studies of six commercialization projects (the supersonic transport, satellite technology, the space shuttle, the Clinch River breeder reactor, the synfuels project, and the photovoltaics commercialization program), and concluded, "The overriding lesson from the case studies is that the goal of economic efficiency—to cure market failures in privately sponsored commercial innovation—is so severely constrained by political forces that an effective, coherent national commercial R&D program has never been put in place" (Cohen and Noll 1991, 378).

2. A more complete description of the innovation process would begin with infrastructure—intellectual property rules, standards, education—that enables innovation, and divide the R&D stage into an early basic research and exploratory development effort, and a later development and advanced energy effort.

3. See White House n.d., Table 9.8. The data for the earlier period include DOE demonstration projects, whereas the data for recent budget years do not count stimulus funds. If the stimulus demonstration projects are included, the totals would be comparable.

4. Most of this later-stage R&D is performed by industry, but DOE national laboratories perform a significant fraction. The national labs have enormous technical capability. But, because they are not connected to energy markets and have a culture that stresses technology rather than cost, there have long been questions about how best to manage the energy programs of the non-weapons laboratories. This is an important but complicated matter that is not the subject of my paper.

5. According to the Energy Information Administration (EIA; 2011), U.S. consumption of gasoline in 1987 was 7,206,000 barrels/day.

6. Energy projections to the year 2000—July 1982 update—DOE/PE-0029/1. This same document projected a range of 130–169 GWe U.S. nuclear power capacity in the year 2000; in fact it turned out to be about 100 GWe.

7. DOE support for large DOE synfuels demonstration plants—Exxon Donor Solvent (EDS) and Solvent Refined Coal (SRC) I and II—was terminated in 1981 and 1982 after vast expenditure.

8. The DOE FY2012 budget submission contains the following summary of all loan guarantee commitments:

   "As of January 2011, the DOE Title XVII Loan Guarantee Program has awarded conditional commitments or closings to 18 projects totaling over $17. 6 billion in the following sectors:

   • Solar generation: three projects totaling $3. 8 billion in loans
   • Solar manufacturing: two projects totaling $935 million in loans
   • Wind generation: two projects totaling $1. 4 billion in loans
   • Wind manufacturing: one project with a $16 million loan
   • Geothermal: two projects totaling $200 million in loans
   • Transmission and Energy Storage: three projects totaling $409 million in loans
   • Biofuels: one project with a $241 million loan
   • Energy efficiency: two projects totaling $317 million in loans
   • Nuclear power facilities: one project with a $8. 3 billion loan
   • Front-end nuclear facilities: one project with a $2 billion loan"

9. Private communication from the Office of the Chief Financial Office, DOE, March 26, 2011. Two caveats about these data: the Office of Science totals include high energy and nuclear physics and performers may subcontract to other entities—a potentially large (but unknown) effect. An example of this is DOE lab subcontracts to industrial concerns.

10. This raises the question of diffusion of information to international competitors.

11. Here the motivation is government encouragement of energy innovation. Much has been written on the broader question of how the process of government encouragement of civilian technology might be improved with the objective of improving economic competitiveness. For a still relevant discussion, see "The Government Role in Civilian Technology" (1992).

12. Senator Jeff Bingaman, chairman of the Senate Energy & Natural Resources Committee, is champion of the CEDA approach. See, for example, U.S. Senate Committee on Energy & Natural Resources (2009).

13. The Center for American Progress is a leading proponent of energy banks. See Podesta and Kornbluh (2009). See also Center for American Progress Action Fund (2009).

# References


Center for American Progress Action Fund. 2009. "What Is the Green Bank?" Accessed at http://www.americanprogressaction.org/issues/2009/06/green_bank_primer.html.

Cohen, Linda R., and Roger G. Noll. 1991. *The Technology Pork Barrel*. Washington, DC: Brookings.

Department of Energy (DOE). 2012. "FY 2012 Congressional Budget Request." Author, Washington, DC. Accessed at http://www.cfo.doe.gov/budget/12budget/Content/FY2012Highlights.pdf

Department of Energy (DOE). n.d.a. "ATVM [Advanced Technology Vehicles Manufacturing]." Loan Programs Office. Author, Washington, DC. Accessed at http://lpo.energy.gov/?page_id=43

Department of Energy (DOE). n.d.b. "Our Mission." Loan Programs Office. Author, Washington, DC. Accessed at http://lpo.energy.gov/?page_id=17

Department of Energy (DOE). n.d.c. "Pillars of the Recovery Act." DOE Recovery & Reinvestment. Author, Washington, DC. Accessed at http://www.energy.gov/recovery/pillars.htm

Energy Information Administration (EIA). 2011 (July 29). "Petroleum & Other Liquids." Accessed at http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=MGFUPUS2&f=A.

"The Government Role in Civilian Technology: Building a New Alliance." 1992. Report of a panel chaired by Harold Brown. Washington, DC: National Academies Press. Accessed at http://books. nap. edu/catalog. php?record_id=1998

Lester, R. K., and D. M. Hart. 2011 (April). "Energy Innovation: The Great Unlocking." Unpublished paper. Industrial Performance Center, MIT, Cambridge, MA.

Peter Ogden, John Podesta, & John Deutch. 2008 (Winter). "A new strategy to spur energy innovation." In Issues in Science & Technology. Washington, DC: National Academy Press. Also available as a Center for American Progress paper at http://www.americanprogress.org/issues/2008/01/pdf/energy_innovation.pdf

Podesta, John, and Karen Kornbluh. 2009 (May 21). "The Green Bank: Financing the Transition to a Low-Carbon Economy Requires Targeted Financing to Encourage Private-Sector Participation." Accessed at http://www.americanprogress.org/issues/2009/05/green_bank.html.

Romer, Paul M. 1993. "Implementing a National Technology Strategy with Self-Organizing Industry Investment Boards." In Brookings Papers on Economic Activity, no. 2, 345, edited by Paul M. Romer and Zvi Greliches.

Stavins, Robert. 2010 (October 21). "An Economist's View of the Environment, Both Are Necessary, But Neither Is Sufficient: Carbon-Pricing and Technology R&D Initiatives in a Meaningful National Climate Policy." Accessed at http://belfercenter.ksg.harvard.edu/analysis/stavins/?p=827.

U.S. Congress. 1986 (April 7). "Termination of United States Synthetic Fuels Corporation Act." P.L. 99-272, Title VII, Subtitle E, 100 Stat. 143.

U.S. Senate Committee on Energy & Natural Resources. 2009 (July 22). Press Release. Bingaman on Investments in Clean Energy Technology. http://energy.senate.gov/public/index.cfm?FuseAction=PressReleases.Detail&PressRelease_Id=f85df78d-4766-4455-bbee-c298b360dd5b

White House. n.d. "Historical Tables." Accessed at http://www.whitehouse.gov/omb/budget/Historicals.

THE HAMILTON PROJECT

## ADVISORY COUNCIL

# Highlights

John Deutch of the Massachusetts Institute of Technology proposes a series of best practices for government support of technology demonstration and a new institution, the Energy Technology Corporation (ETC), that would bear responsibility for selecting and managing technology demonstration projects.

## The Proposal

**Technology demonstration that generates critical knowledge and options for the private sector.**
Technology demonstration is a key step in the energy innovation process because it generates technical, cost, and environmental information, and provides a range of possibilities for the application of energy R&D. The government would provide a valuable service by supporting and executing technology demonstration projects.

**An independent organization with private sector expertise.**
The ETC would be financed for one ten-year term (subject to renewal) and would have the authority to hire technical and financial experts from the private sector. It also would develop a sophisticated simulation capability and evaluation metrics that would enable it to assess technology programs before and after those programs are completed.

**Clarity of purpose and credibility.**
Technology demonstration projects would be selected for clear, specified reasons, and would be managed and financed using commercial practices that are credible to the private sector.

## Benefits

Independence and expertise would enable the ETC to select and credibly carry out the most promising technology demonstration projects. Following best practices and incorporating lessons from previous technology demonstration efforts would ensure that the ETC contributes to and accelerates the energy innovation process.

THE HAMILTON PROJECT

1775 Massachusetts Ave., NW
Washington, DC 20036

(202) 797-6279

BROOKINGS