Putting Energy Innovation First

Recommendations to Refocus, Reform, and Restructure the U.S. Department of Energy

April 2013

The Clean Air Task Force

The Clean Air Task Force is a nonprofit organization dedicated to reducing atmospheric pollution through research, advocacy, and private sector collaboration.

Energy Innovation Reform Project

The Energy Innovation Reform Project is a nonprofit organization working to promote the development of advanced energy technologies and practices that will improve the affordability, reliability, safety and security of American energy supplies and our energy economy.

Introduction

It is widely accepted that America's global scientific, technical, and economic leadership depend on high-quality education, world-class scientific research, competitive markets, and entrepreneurship. Robust innovation, which is dependent on those factors (among others), is almost universally regarded as a prerequisite for American success in an increasingly competitive global market.

The large corporate R&D laboratories of the 1950s and 1960s run by corporations such as AT&T, Westinghouse, IBM, Exxon, and General Electric, have all arguably declined in scope and ambition as their parent organizations turned toward maximizing shareholder value in the shorter term, deemphasizing long-term R&D. Today, there is no private sector laboratory comparable with the old Bell Labs that won seven Nobel prizes, invented the transistor and the laser, and first demonstrated a practical solar photovoltaic cell. Importantly, Bell Labs was known for *both* its basic research activities and its applied research and development activities leading to commercial products.

Meanwhile, the venture capital markets that helped drive transformations of the telecommunications and information technology industries have had only marginal effects on innovation in national and global energy systems, despite some very high profile efforts. This is not surprising since venture capital investments tend to involve numerous, smaller tranches of investment funding made over a limited period of time. Energy investments at scale often require large, "lumpy" investments made over a long time.

With the departure of the private sector from many aspects of basic and applied energy research, many have looked to the Department of Energy's national laboratories to fill the void. As policymakers debate the appropriate role for government in support of innovation, questions often arise about the basic capabilities of the Department of Energy (DOE) and its laboratories. This paper explores DOE's role and structure and the opportunity to fundamentally reshape the department in ways that could significantly improve its effectiveness.

An Underperforming Agency

The Department of Energy is by far the largest funder of research in the physical sciences in the United States. DOE's government-owned, contractor-operated National Laboratories are irreplaceable national assets that host one-of-a-kind scientific instruments and impressively talented scientists. This network of laboratories and people are, or should be, a key component of America's "innovation infrastructure."

But have DOE and the national laboratories delivered the goods? Critics lodge a variety of complaints, ranging from the difficulty and expense of working with the labs to their lack of focus on issues of relevance to the twenty-first century economy. Others assert that any problems with the laboratories are primarily the fault of Department of Energy, which manages the labs and most of their programs.

Congress and successive presidential administrations have attempted to address some these complaints through a variety of efforts. Yet, in spite of new institutional arrangements (e.g., ARPA-E, Energy Innovation Hubs, Energy Frontier Research Centers), new statutory authorities (e.g., loan guarantee authority, other transactions authority), and significant funding provided by the American Recovery and Reinvestment Act of 2009 ($32.7 billion in funding and $2.5 billion in credit subsidy support), the Department of Energy continues to underperform against expectations with respect to advancing new energy technologies in the marketplace.

Some of DOE's failures are notable (e.g., Solyndra). Other DOE-supported programs have demonstrated significant technical successes, but have not yet had significant commercial impact in the market (e.g., fuel cell research, underground coal gasification, and advanced nuclear reactor designs). However, to be fair, many DOE programs have contributed to technical success *and* new/improved commercial products and processes. Examples of these contributions include the Advanced (Natural Gas) Turbine Program, the development of low emissivity (low e) window glass, early work on advanced oil and gas drilling and extraction ("fracking") technologies, and elements of the clean coal power initiative focused on conventional environmental controls. While these successes have tended to be "evolutionary" rather than "revolutionary," it is nevertheless useful to identify and understand the institutional conditions and arrangements for private sector collaboration that played a role in these contributions.

Refocusing DOE: Putting Energy Innovation First

The national discussion about energy, like other issues, is highly politicized. It would be naïve to believe that the reforms we advocate could free DOE entirely from political pressures and pork-barrel politics and allow it to transform the energy landscape by itself. But despite those realities, we do believe that government can play a vital role in catalyzing technological innovation in the future, as it has in the past.[1] The key to progress, and the overarching spirit of our recommendations, is to ensure that the goals and technical milestones of government-assisted energy research and development are established not by elected officials and political appointees but by scientists and engineers working in collaboration with private-sector energy technology providers.

Irrespective of the direction of future political winds, DOE and the national laboratories are unlikely to disappear. Despite the partisan divisions that inhibit bolder actions, all parties should be able to agree that *DOE is an agency that must perform much better in the future than it has in the past*. The administration and Congress should seize the opportunity to *reform, restructure, and revitalize DOE and its network of national laboratories*.

[1] Even if most Americans do not recognize it, government has made (or contributed to) significant technological breakthroughs we employ every day. The smart phones in our pockets, if they existed at all, would be vastly different in the absence of government-funded inventions and innovations in GPS, chip technology, network design, optics and display. Government has also played similarly important, if perhaps less visible roles, in energy technology.

Energy Innovation Challenges at the Department of Energy

- **As its budget clearly illustrates, energy research is a comparatively low priority at the Department of Energy.** The Department's missions related to nuclear weapons and legacy environmental cleanup from nuclear weapons production demand more money, and more leadership attention, than the energy innovation and science missions.

- **DOE's institutional structure inhibits effective innovation.** DOE's "basic" and "applied" energy research and development activities are managed across a variety of offices, under the direction of different under secretaries. These activities are not well coordinated, nor are they guided by an enduring, objective portfolio review process. *Linking these activities under a common, coherent organizational structure is imperative.*

- **There is no enduring, systematic effort to bridge the gaps between basic research activities and applied technology challenges.**

- **DOE's applied energy efforts are divided into technology-specific "stovepipes"** (e.g., Office of Fossil Energy, Office of Nuclear Energy, Office of Energy Efficiency and Renewable Energy, Office of Electricity Delivery and Energy Reliability) **that promote factionalism rather than focusing on innovation that meets America's energy needs.**

    - Each of these offices, organized as they are around primary energy *sources* (nuclear, fossil, renewable) rather than *uses* (power, transportation), demonstrate a predictable bureaucratic tendency to become a cheerleader for their particular energy source rather than pursuing the most promising technology solutions in a more holistic context. Each of these "stovepiped" offices—headed by a presidentially-appointed assistant secretary—maintains its own analytical organization, budget shop, public affairs activity and congressional relations activity. Each of these offices also nurtures a population of interested stakeholders (and rent-seekers) offering political support for their congressional appropriations. Consequently, budget recommendations and congressional appropriations are made through a process that is far more political and/or ideological than analytical.

- **DOE lacks basic mechanisms for setting objective, long-term strategic goals and evaluating progress toward them.** There are only occasional and narrow outside reviews of specific DOE programs by bodies such as the National Academies/National Research Council. Inside DOE, there is no enduring top-level planning/evaluation/technical assessment function, insulated from political influence and employing a common set of metrics to objectively evaluate the applied energy programs and the basic science activities that support them. Instead, each program's own analytical organizations "grade" themselves.

- **DOE political leadership generally crafts inherently political, self-assessments** as part of an administration's larger political messaging efforts. As one might expect of such self-evaluations, all DOE programs score highly, despite the fact that their impact in the marketplace is underwhelming at best, or a waste of resources at worst.

- Given the lack of impartial, systematic program review, it is not surprising that successive administrations exhibit a **"flavor of the month"** approach to investments in innovation, often **advancing vastly different technological approaches** (e.g., hydrogen, biofuels, vehicle electrification) **for ideological, political, or other reasons.**

- **The Office of Science**, responsible for most basic research at DOE, conducts a broad variety of activities in biological science, computational science, nuclear physics, fusion energy sciences, high-energy physics, and basic energy sciences. While basic scientific research in other fields can lead to unexpected advances in energy innovation, the **Office of Science arguably has no unifying strategic vision or framework. We believe this has permitted an imbalance to develop favoring "science for the sake of science" at the expense of science for the sake of energy and technology innovation.**

- The DOE Laboratories, almost all of which are designed to be Government Owned, Contractor Operated (GOCO) laboratories, **have been subjected to such relentless micromanagement by DOE that they have lost the essential character of a GOCO.** Instead of articulating the mission and strategic goals of the labs and allowing the Lab's Management and Operating contractors the freedom to determine how to best accomplish those goals, DOE has instead, over the course of many years, layered a confusing system of directives, requirements, and approval mechanisms upon the labs. **Instead of evaluating success in achieving desired *outcomes,* DOE has instead tended to review and approve *transactions* and to audit adherence to DOE directives.** This deterioration of the GOCO model was identified in the 1995 Galvin Task Force on Alternative Futures for the DOE National Laboratories. A 2003 DOE Blue Ribbon Commission noted that this deterioration had continued.

- Because energy investments occur in the private sector, **DOE must have a strong understanding of technology challenges and opportunities in the global commercial realm.** Most DOE-private sector interactions take place in the narrow context of DOE funding opportunities, where DOE and/or the Congress have determined what kinds of activities should be funded. There is a greater need for DOE to engage in **earlier-stage, collaborative discussions with global marketplace energy providers in planning the relevant basic and applied research that could yield the greatest benefits for technology advancement**. The challenge is do this without becoming captive to individual corporate interests or promoting "corporate welfare." Put simply, DOE needs to thoughtfully invigorate and expand activities designed to interact with private industry in collaborative, pre-commercial research initiatives. Ultimately, these activities should arguably comprise a significant portion of DOE energy research.

- **As currently structured, DOE's international activities are of limited value—despite the fact that the fastest growing markets for energy, with the greatest opportunities for innovation, are overseas.** DOE has signed literally hundreds of bilateral and multilateral agreements with other countries and international agencies designed to foster cooperative research and development, but these agreements are typically more ceremonial than substantive. Many are opportunistically conceived and signed when the Secretary of Energy is visiting a foreign nation, or when a foreign Energy Minister is visiting DOE. Such agreements bear little fruit and are quickly forgotten, and yet they are currently a major activity of the DOE International Programs Office.

- **DOE's has maintained a generally poor record of executing commercial scale "first-of-a-kind" (FOAK) commercial technology demonstrations.[2] New institutional arrangements are therefore necessary.**

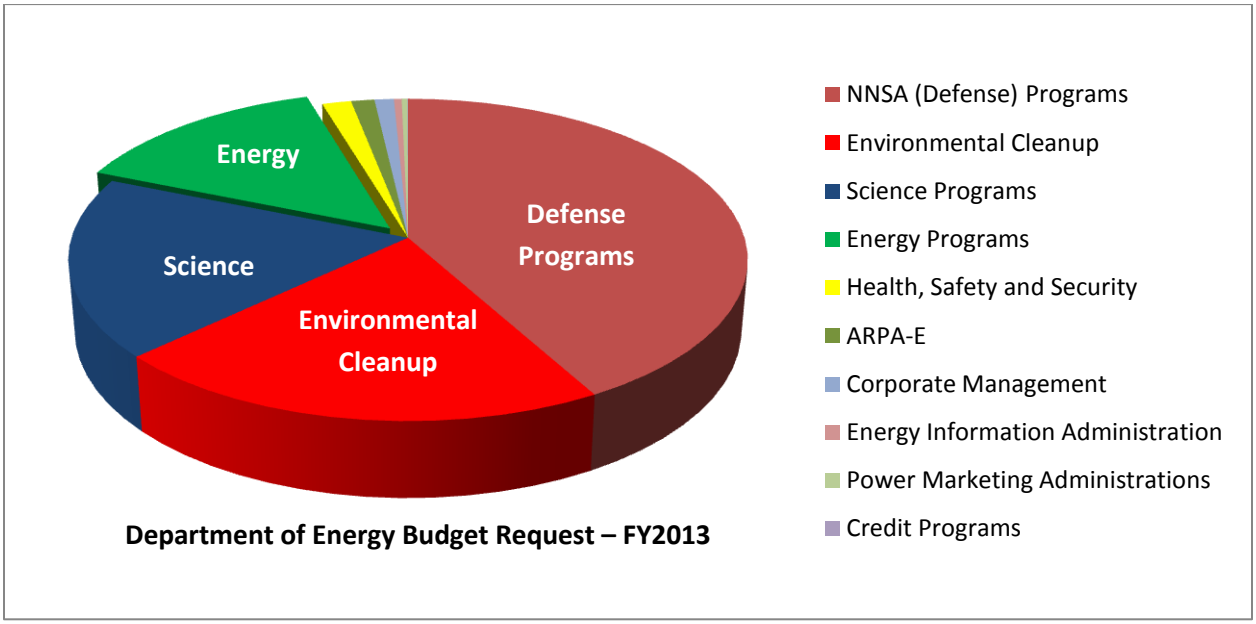
The balance of this paper explores these key challenges in greater detail, offering some relevant suggestions for reform for consideration by Congress and administration.

[2] DOE has succeeded in a few FOAK demonstrations, but it is important to understand why these are the exceptions rather than the rule. For example, the Polk County and Wabash River Integrated Gasification Combined Cycle, or IGCC plants have successfully demonstrated new technology at commercial/near-commercial scale. Another DOE-supported IGCC plant near Reno, NV, however, was abandoned. The successful projects, along with a number of component-scale demonstrations (e.g., low-NOx burners, flue gas desulfurization) were executed under the Clean Coal Technology Demonstration Program, which was launched in 1986 to address acid rain. The successes of this program were arguably attributable in large part to its unusual circumstances: It had the benefit of advance appropriations that were difficult for subsequent Congresses to redirect, coupled with the earnest congressional protection of the program embodied in the personage of the late Senator Robert C. Byrd.

Energy as an Afterthought at DOE

CHALLENGE: As its own budget clearly illustrates, energy research is a comparatively low priority at the Department of Energy. The Department's missions related to nuclear weapons and the legacy environmental cleanup from nuclear weapons production demand more money, and more leadership attention, than the energy innovation and science missions.

Follow the money is almost always good advice in Washington. Judged by its spending, the U.S. Department of Energy is, in reality, the Department of Nuclear Weapons, Radioactive Cleanup, Physical Sciences, and Energy. It is also engaged in nuclear non-proliferation activities, as well as the design and construction of naval nuclear reactors. But defense programs and remediation of environmental damage at nuclear weapons production-related sites constitute the majority of DOE funding, as illustrated in the figure below.



Department of Energy Budget Request – FY2013

It is also often said in Washington that an agency's budget is its premier policy statement and (at least) a first-order approximation of the distribution of the agency leaders' time and attention. At DOE, this is generally true, but some DOE missions, owning to their "radioactivity" (in both literal and political terms), consume a disproportionate share of the Department leadership's attention.

For example, due to the Department's obligation to remediate and manage the legacy of the nuclear weapons/fissile materials production sites; the relatively large amounts of funding allocated to the effort (approximately $6 billion annually); and the political sensitivities aroused by radioactive contamination and release, DOE's environmental management activities alone can consume a great deal of the agency leadership's time and attention. The same can be said of the nuclear weapons mission, the nuclear nonproliferation mission, and the host of occupational health, safety, and security requirements

related to those missions. Collectively, they are an enormous distraction from the subject of energy in general, and energy innovation in particular.

While we would advocate a greater level of funding for basic and applied energy research than is currently allocated to these missions, we are cognizant of fiscal realities and the difficulties of securing discretionary spending increases for those purposes. If Congress and the Administration cannot (or are not inclined to) provide the Department with significant amounts of new money—*and especially if they can*—they should provide the Department's leadership with the ability to focus more intensely on the energy and innovation missions by freeing them from some of their other responsibilities.

Therefore, we recommend that the Department of Energy be transformed, as much as possible, into an agency that is exclusively focused on energy, science, and innovation. The nuclear weapons, environmental cleanup, and defense missions are often distractions for DOE leadership, and contribute little to energy innovation. There are some exceptions, of course; the work on nuclear weapons stockpile stewardship has contributed to advances in supercomputing and plasma physics with implications for energy research. But this is the exception rather than the rule.

To promote a greater focus on energy innovation at DOE, we recommend the following:

- **Move the nuclear weapons, naval reactors, and nuclear nonproliferation missions to the Department of Defense**.

    - Nuclear weapons and naval reactors are, after all, weapons systems, and the Department of Defense has ample experience in the procurement of advanced and complex systems, including highly classified systems. It is also important to understand that DOE is a contract management operation that outsources its activities to a variety of contractor-operators who perform the actual work—whether that work is rebuilding or dismantling a nuclear weapon, cleaning up contaminated soil, or operating a national laboratory. There might be an argument for housing these disparate and complex missions in a single agency that has demonstrated a particular capacity for superb project, program, and contract management—but DOE has a generally undistinguished record in this regard, particularly in light of recent cost overruns associated with nuclear weapons re-engineering efforts[3] and ongoing security lapses at weapons facilities.[4] Since these activities are largely contracted out, and since the government contract managers

[3] For example: The program to re-engineer the B61 nuclear weapon, comprising 400 of the roughly 5,100 warheads and bombs in the U.S. nuclear arsenal, will cost as much as $10 billion—more than double preliminary estimates—according to the *Washington Post*.

[4] The most recent in a long history of security failures at DOE weapons facilities occurred on July 2, 2012 when an 82-year-old nun and two other antiwar activists allegedly breached multiple security perimeters to reach a DOE/NNSA facility containing highly enriched (bomb grade) uranium. The DOE Inspector General "identified troubling displays of ineptitude in responding to alarms, failures to maintain critical security equipment, over reliance on compensatory measures, misunderstanding of security protocols, poor communications, and weaknesses in contract management."

in the Department of Defense have specialized experience in weapons systems procurement, it is difficult to accept the argument that these functions can be housed only at DOE, or that DOE can perform them better than DOD.

- Some will argue that such a move would weaken the long-held doctrine of civilian control of nuclear weapons. While the issue will certainly be debated, there is no objective reason why this concern should be decisive: The Department of Defense itself is civilian-controlled, and nothing about this move would change the rules and protocols governing the use of nuclear weapons, or the role of the President or the National Command Authority governing the use of nuclear weapons. An argument may be made that this concern is largely a fading artifact of the Cold War era.

- **Move the environmental cleanup mission to the Army Corps of Engineers or even the Environmental Protection Agency**.

  - As noted, DOE uses contractors to manage and conduct cleanup activities. EPA or the Army Corps can easily do the same.

  - The Army Corps of Engineers has experience performing environmental remediation, including projects involving radioactive contamination.

  - Were EPA to be made responsible for actually conducting clean-up activities, pursuant to the rules and guidance it promulgates for others, it might gain a richer, first-hand perspective on the costs and benefits of its own regulations, leading to more practical, realistic approaches to regulating environmental cleanup. Some may argue that EPA should not be allowed to regulate itself in these projects. There are multiple checks and balances, however, to protect against the danger of an unaccountable EPA. In addition to congressional and presidential oversight, affected States and other parties will retain access to judicial review and remedy should a situation arise where EPA's applications of its rules for its own cleanups are less rigorous than what it requires for others.

Naturally, this narrowing of focus and mission would present implementation challenges, particularly at DOE field sites that host activities ranging across the full spectrum of DOE's current work. For instance, at Savannah River National Laboratory, there are energy, science, nuclear weapons, and environmental cleanup activities simultaneously underway. Critics of our recommendation will argue that three different entities (Defense, Corps of Engineers, and Energy) would have to manage and coordinate the work flow at the site, creating conflict and inefficiencies. But the work at these field sites is already conducted by outside contractors, and much of the work is managed as fairly discrete work packages. So it is already important to coordinate this work at each site to take advantage of synergies or avoid conflicts; DOE site offices already do this when they balance the needs and requirements of, for example, an Office of Science activity and a National Nuclear Security Administration activity underway at the same site.

In other words, in our example, the Savannah River Site and Operations Office are coordinating activities that have been contracted for by different DOE offices. If these activities were spun off to other agencies, the coordinating function would remain largely unchanged; the difference would be that the "clients" would be offices in another agency. Budget authority (as well as liabilities) would have to move from the DOE to the agency responsible for the work, but the contractors performing the actual work would likely remain the same, simply reporting to a different agency. Over time, some agencies would choose to cease operations at a given site (as the Army Corps of Engineers or EPA would when a cleanup was completed) or consolidate work from elsewhere into or out of a given field site. This would have the beneficial effect of "rightsizing" the DOE complex over time, since other agencies will be less inclined to remain responsible for "overhead" costs at facilities that do not contribute to their core mission.

But it is not enough to simply transfer current missions from DOE to other agencies. Efforts need to be undertaken to reform and restructure the activities that remain by addressing a variety of issues that have adversely impacted the performance of the Department and its energy innovation mission. We turn to those issues now.

The Gaps between Basic and Applied Research at DOE

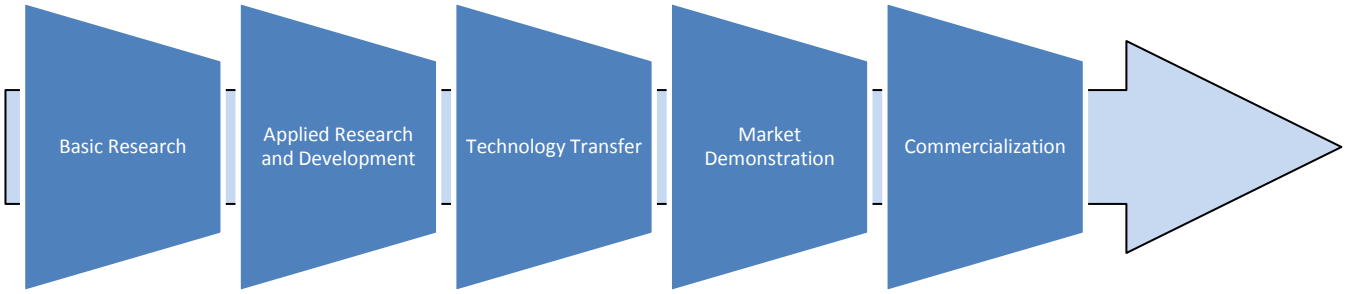
CHALLENGE: DOE's "basic" and "applied" energy research and development activities are managed by a variety of offices, under the direction of different under secretaries. These activities are not well-coordinated, and they are not guided by an enduring, objective portfolio review process.

CHALLENGE: There is no enduring systematic effort to bridge the gaps between basic research activities and applied technology challenges.

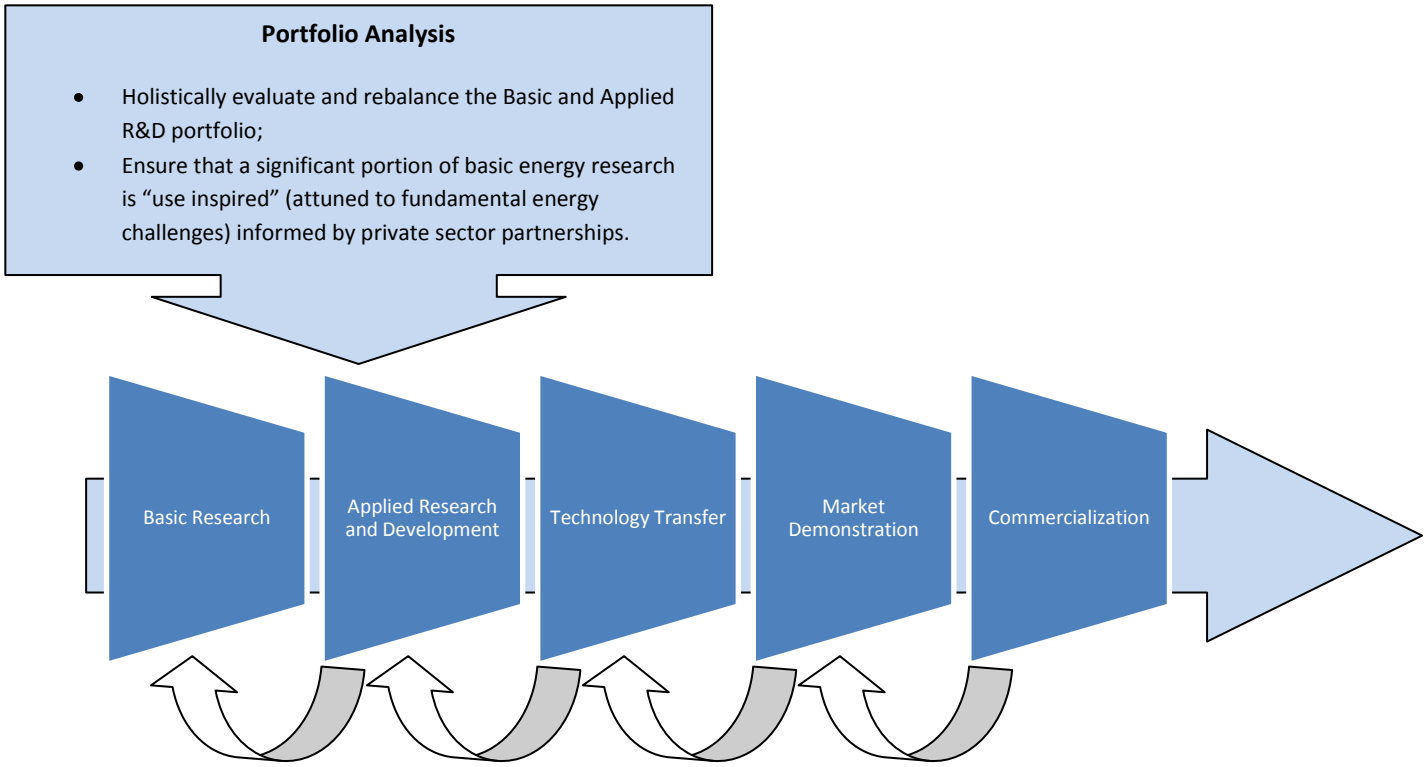
DOE's applied energy programs fall within the purview of the Under Secretary of Energy, while basic science programs report to the Under Secretary of Science. Not only is this bureaucratically complex, it inhibits the strong linkages and feedback interactions that need to occur between the basic and applied research programs.

Also, *there is no institutionalized, enduring process to review the R&D portfolio at DOE*. Having recognized the importance of doing so, a number of DOE under secretaries have attempted to undertake such a review. During the Clinton and George W. Bush administrations, two different under secretaries of energy initiated comprehensive portfolio reviews, but neither was completed. After the President's Council of Advisors on Science and Technology (PCAST) recommended that the Obama administration undertake a Quadrennial Energy Review (QER), DOE Under Secretary Steve Koonin was successful in completing a narrow aspect of the QER in 2011, a partial portfolio review called the Quadrennial Technology Review (QTR). This was a limited effort, however, in that it never aspired to suggest concrete budgetary adjustments to rebalance the DOE R&D portfolio in accordance with its findings; nevertheless, it was an important first step that can be built upon.

In addition to viewing and managing its R&D portfolio as a whole, DOE must also promote greater interaction and feedback between the basic and applied activities in order to strengthen the so-called "innovation chain," moving further from the model of the Weak Innovation Chain toward the Strong Innovation Chain, as illustrated below:



Weak Innovation Chain: The Office of Science is mainly active in Basic Research; the Applied program offices are mainly active in Applied Research and beyond. Efforts are largely uncoordinated.



Strong Innovation Chain: The Basic and Applied activities are coordinated, evaluated by a Portfolio Analysis process and informed by needs and experiences in the technology transfer, market demonstration, and commercialization phases.

The "innovation chains" illustrated above are simplistic representations of reality, and it is admittedly an oversimplification to describe DOE's research activities as fitting neatly within "basic" or "applied" categories; nevertheless, we can generally observe:

- Most **basic research**—programs in biological science, computational science, nuclear physics, fusion energy sciences, high-energy physics, and basic energy sciences—is managed by the Office of Science. Typically, the Office of Science supports activities in universities and national laboratories, and much of its funding is disbursed through an annual, broad, open solicitation that covers all of its research areas.

- **Applied research** and technology development/deployment is typically performed in DOE laboratories and by industry, most often in the context of narrow funding solicitations aimed at improving the performance of an existing technology, often in accord with a multiyear program plan in pursuit of specific technical and cost goals.

These two fundamentally different approaches do not encourage focused collaboration and information sharing between basic and applied activities. This has slowly begun to change as the Office of Science

has felt the need to focus more attention on questions of "national need" (e.g., energy) rather than general discovery. For example, the Office of Science has recently increased its collaboration with the applied energy programs in an effort to address challenges such as developing novel methods of low-cost energy storage or carbon capture. But even where these collaborative efforts have occurred, DOE's tendency has often been to distribute small increments of funding like seeds on the wind, rather than engaging in a truly focused, coordinated campaign.

The Energy Innovation Hubs established by the Obama administration, and their precursors, the Bush administration's Bioenergy Centers, were designed to address this problem by emulating the more fully integrated R&D approaches of the prominent corporate research laboratories of the past. Each center is intended to focus on a specific area (e.g., energy storage), and aspires to bring together under one roof the best minds from universities, national laboratories and industry to collaborate on various aspects of the innovation chain from basic discovery through product development. The Bush administration's Bioenergy Research Centers brought researchers from various institutions together in a concerted, multi-year effort, and there are indications that these centers are beginning to bear fruit. The Obama administration's Energy Innovation Hubs are similarly structured, multi-year efforts, with management structures more directly modeled on historic corporate research labs, with directors empowered to shift funding between different approaches, between basic and applied activities, and between member institutions. They are also expected to forge close working relationships with industrial partners that will commercialize products derived from their research.

While it is too early to judge their success or failure, the Energy Innovation Hubs do face some significant challenges:

- Their funding is relatively modest. While $25 million per hub per year may sound like a great deal of money, it is small relative to the challenge of significantly impacting the global energy enterprise.

- Because the open competitions to host a hub have been won by teams drawn from multiple institutions, they have not always resulted in the research participants being co-located together in the collaborative model of the old corporate research labs. Modern communications technology may mitigate that weakness to some extent, but most researchers believe that the best collaboration occurs when team members work in close proximity, interacting formally and informally, on a day-to-day basis.

- The fact that there are many different institutions involved can also produce impediments to the free movement of personnel between partner institutions, and there is the danger of disputes over shared ownership of intellectual property—issues that were less likely to occur in the corporate labs of the past since everyone worked for the same company.

We believe that DOE is on the right track with the Bioenergy Centers of the Bush administration and the Energy Innovation Hubs of the Obama administration. But that raises the question: *If DOE is on the right*

path with this approach, how might the Energy Innovation Hub concept become a more dominant approach—the rule rather than the exception—for DOE-supported energy research and development?

The creation of the Hubs was, at least in part, a "workaround" to avoid the laboratory performance problems driven by the deterioration of the GOCO laboratory governance model described earlier. But is it better to pursue Innovation Hubs as alternatives to the labs, or to instill within the DOE-Laboratory relationship some of the more essential characteristics of the Hubs? The answer, as we recommend below, is to challenge the national laboratories to meet discrete energy innovation challenges by making those objectives explicit elements of their core mission and contract objectives, by freeing them from excessive transactional micromanagement, and by bridging the basic and applied work through innovative teaming arrangements between labs.

Recommendations:

- **The Energy and Science programs should be consolidated under a single Under Secretary for Energy and Science.** The other under secretary slot should be eliminated, or reconstituted as the Under Secretary for Policy, Management, and Administration to relieve the deputy secretary of some of the approximately 25 positions that report directly to the deputy secretary.

    - The new Under Secretary for Energy and Science should periodically undertake an **energy technology portfolio review** that evaluates the DOE technology development portfolio, identifies imbalances, makes transparent recommendations for budget adjustments—and justifies them.

    - The portfolio review should **identify key basic technology challenges** (i.e., energy storage) **that are likely to require fundamental scientific breakthroughs**.

    - In keeping with our recommendation to more closely align DOE research activities with real innovation challenges in the private sector, the Under Secretary for Energy and Science should establish a **Federal Advisory Committee comprised of chief technology officers and other representatives of private sector providers** of power, fuels, energy services, buildings, and vehicles.

- **National laboratories should be operated, singly or through teaming arrangements between labs, more like large energy innovation hubs, with clearly designated roles or areas of responsibility in a specified realm of energy technology development, or one or more of the fundamental technology challenges. These roles can be explicitly embodied in the lab's M&O (Management and Operations) contract as a core element of the laboratory's mission, or through a secondary contract vehicle that joins appropriate elements of multiple labs in a focused programmatic effort.**

- **DOE should evaluate the labs on their progress in overcoming technology challenges and other strategic outcomes, ending its micromanagement of the labs while working to restore the true GOCO governance model.**

    - DOE should also, through new or existing contracting mechanisms, **replicate the Innovation Hubs model on the scale of a national lab** (or elements from a group of labs) by choosing, through a competitive process, **a multipurpose science laboratory** (or portions of those labs, or teams of two or more labs) **to focus on key energy challenges**. This mission can, and arguably should, be explicitly written into the laboratory's mission in the lab's M&O (Management and Operations) contract competition. However, it is also possible to award fundamental *energy challenge missions* through a secondary contract competition under which the winning lab(s) could be given a 5-year contract and budget, with an option for a second 5-year period based on performance. It would be critically important to allow these larger, lab-centered efforts—call them **Energy Innovation Centers** for the purpose of this paper—to be given the *freedom and flexibility to shift resources, move freely between basic and applied work, and generally be free from DOE program office micromanagement*.

      Most DOE laboratories are multipurpose labs with varied capabilities, but some focus on particular energy market segments. For example, the National Renewable Energy Laboratory (NREL) focuses on the advancement of renewable energy and energy efficiency technologies. But NREL is almost exclusively an "applied" energy technology laboratory, and its primary DOE sponsor is the Office of Energy Efficiency and Renewable Energy. Its collaborative interactions with the Office of Science (and consequently, with fundamental and potentially transformative basic science) are generally weak. The same can be said of the National Energy Technology Laboratory (NETL), sponsored by the Office of Fossil Energy, which is focused almost exclusively on fossil energy challenges such as carbon capture and sequestration. Crucially, some of the very best and potentially transformative basic work in energy efficiency, renewable energy, and carbon capture is not performed by NREL and NETL, but rather at labs managed by the Office of Science.

      Organizing the department's basic and applied activities under a single under secretary, coupled with measures to eliminate the energy technology "stovepipes" (as recommended below) will **reduce the institutional barriers to basic-applied collaboration** that have inhibited progress in area-focused labs such as NREL and NETL. For example, in the absence of existing technology "stovepipes" and the institutional divisions between basic and applied work at DOE, secondary contract mechanisms could be more easily employed to team elements or activities in a basic science lab with elements or activities in an applied research lab in pursuit of a common goal, such as overcoming a fundamental energy challenge.

- *The work of energy innovation hubs and the larger energy innovation centers must also be linked to the private sector's real-world challenges in meeting energy and consumer needs*. Therefore, the work of DOE labs, innovation hubs and innovation centers should be undertaken in the context of **partnerships with the private sector engaged in the delivery of energy and energy services**. We make recommendations pertaining to those partnerships below, but discuss the concept here to emphasize that the work of DOE labs must be relevant to product development and oriented toward technology transfer to be useful in the marketplace.

- **The Advanced Research Projects Agency–Energy (ARPA-e) is a young but promising effort that, freed from the constraints of basic- and applied-energy office cultures, seeks to identify, fund, and advance targeted technology breakthroughs that might be capable of commercialization in relatively short order.**

  - It is too early to judge the success or failure of ARPA-e in promoting new energy technologies and innovation. But ARPA-e has already shown the rest of DOE, particularly the applied program offices, that it is possible to crisply execute funding opportunity announcements, selections, contracts, technology "downselects" and project cancellations when progress stalls. From a *process* standpoint, at least, ARPA-e has performed well thus far and deserves to continue.

  - We also believe ARPA-e should continue to exist as a stand-alone entity reporting to the Secretary of Energy, although it should work to avoid direct duplication of specific activities in the Office of Science and the applied energy programs.

  - We do not believe that ARPA-e is a viable substitute for many activities in the applied program offices, such as the development of small modular reactors or other *technologies that require sustained, multiyear efforts* beyond the shorter timeframe activities that are more characteristic of ARPA-e investments. Elements of ARPA-e may deserve emulation, but it is not an alternative to deeper reforms.

Applied R&D Today: Fragmented Stovepipes without Honest Analytics

CHALLENGE: DOE's applied energy efforts are organized around technology "stovepipes" (e.g., the Office of Fossil Energy, Office of Nuclear Energy, Office of Energy Efficiency and Renewable Energy, Office of Electricity Delivery and Energy Reliability). Each of these offices, **organized around primary energy *sources*** (nuclear, fossil, renewable) **rather than *uses*** (power, transportation), demonstrate an inevitable tendency to **become a cheerleader for their particular energy source** rather than pursuing the most promising technology solutions in a more holistic context. Each of these stovepiped offices—headed by a presidentially-appointed, Senate-confirmed assistant secretary—is an entity unto itself, with its own analytical organization, budget shop, public affairs and congressional relations staffs. Naturally, each of these offices also nurtures a population of interested stakeholders (and rent-seekers) offering political support for their congressional appropriations. As a result, **budget recommendations and ultimately, congressional appropriations are made through a process that is far more political and/or ideological than analytical.**

CHALLENGE: There are only occasional and narrow *outside* reviews of specific DOE programs by bodies such as the National Academies/National Research Council. ***Inside* DOE, there is no enduring top-level planning/evaluation/technical assessment function, insulated from political influence and employing a common set of metrics to evaluate the applied energy programs and the basic science activities that support them.** Instead, each program is evaluated by its own analytical organization. In addition, DOE's political leadership generally crafts inherently political self-assessments as part of an administration's larger political messaging efforts. As one might expect of such self-evaluations, all DOE programs score highly, despite the fact that their overall impact in the marketplace is underwhelming at best, or a waste of resources as worst**. Given the lack of impartial, systematic internal or external program review, it is not surprising that successive administrations exhibit a "flavor of the month" approach, often advancing vastly different technological approaches** (e.g., hydrogen, biofuels, vehicle electrification) **for ideological or political reasons.**

Recommendations:

- **The four applied energy R&D program offices (Office of Fossil Energy, Office of Nuclear Energy, Office of Energy Efficiency and Renewable Energy, Office of Electricity Delivery and Energy Reliability) should be reconstituted into a new set of fewer offices focused more on energy *end use* rather than primary *energy source*. We believe that two or three could suffice.** For example:

    - An **Office of Power and Grid Technologies** could consolidate the work on power and grid technologies currently housed in the Office of Fossil Energy, the Office of Nuclear Energy, the Office of Energy Efficiency and Renewable Energy, and the Office of Electricity Delivery and Energy Reliability.

- An **Office of Transportation and Fuel Technologies** could consolidate the transportation vehicle and biofuels work currently housed in the Office of Energy Efficiency and Renewable Energy.

- An **Office of Advanced Energy Efficiency Technologies** could host the R&D on building and industrial efficiency that doesn't easily fit in the power/grid or the vehicles/fuels space.

Variations on this theme are certainly possible, and we appreciate the fact that there would inevitably be opposition from nuclear, renewable energy, and fossil energy stakeholders who enjoy having a designated assistant secretary as their champion in congressional and administration budget deliberations. But the stovepipes are clearly detrimental to holistic, collaborative innovation and problem solving; breaking the silos is integral to reform of DOE.

- As indicated earlier, **the Office of Science would also be housed with the applied R&D offices under the Under Secretary for Energy and Science. This would improve opportunities for the collaborative efforts between the basic and applied energy work, and make a single DOE official (the Under Secretary for Energy and Science) accountable for efforts to bridge the gaps between basic and applied activities.**

- **All of the planning, budget, analysis, and congressional/public affairs activities should be removed from the applied program offices. These functions should be carried out at the level of the Under Secretary for Energy and Science, or in the case of congressional and public affairs, at the DOE Corporate level. The new, more "corporate" analytical entity should, in a manner approximating the Energy Information Administration (EIA), be insulated from political and policy pressures.**

  The fact that each of the current applied energy R&D program offices maintains their own budget, analytical, public and congressional affairs offices, without common agreed-upon metrics, is not only wasteful and duplicative; it is virtually guaranteed to generate self-serving analysis that is more likely to frustrate and confuse DOE leadership, the White House, the Congress and the public rather than enlighten them. This "competing/conflicting analysis" problem has contributed to what some have called DOE's "technology flavor of the month" problem. It is a simple matter for successive administrations (or even the same administration) to quickly shift focus, for example, from hydrogen to biofuels to electric vehicles because there is always a cadre of analysts in a program office that can be counted on to produce whatever analysis is needed to justify virtually any initiative that the political leadership at DOE or the White House wishes to pursue. The consolidation of these disparate offices into a single, more politically insulated entity covering all the applied energy R&D program offices, as well as the Office of Science, would promote less parochial, less self-serving, corporate analysis.

The Office of Science: Science for the Sake of Science?

CHALLENGE: The Office of Science, responsible for most basic research at DOE, conducts a broad variety of activities across the spectrum including biological science, computational science, nuclear physics, fusion energy sciences and high-energy physics, in addition to basic energy sciences. While basic scientific research in other fields can be the wellspring of unexpected discovery that can benefit energy innovation, *the Office of Science arguably has no unifying strategic vision or framework*. We believe there is an imbalance favoring "science for the sake of science" at the expense of science for the sake of energy innovation.

Recommendations:

- **Positioning the Office of Science with the applied energy technology programs under a designated, accountable Under Secretary for Energy and Science would elevate and focus the Office of Science's work toward more "use-inspired basic research" complementing the efforts of the applied energy programs.**

  Shifting the planning, budgeting, analytical, and evaluation functions to the under secretary level would make *integrated program planning* with an emphasis on *addressing key grand challenges through basic research* (e.g., energy storage, carbon capture) much more likely, and far easier, than attempting to coordinate such collaborative efforts across disparate institutional silos.

- **We do not recommend, however, that energy research become the *exclusive* focus of the basic research activities of the department.** DOE labs are host to a number of large scientific user facilities that are unique and profoundly important to national and international research that may or may not be energy related. Instead, we encourage *a conscious and strategic effort to elevate use-inspired basic research to complement the efforts of the applied energy programs.*

Public-Private Research Collaborations

CHALLENGE: Because energy investment occurs in the private sector, DOE must have a strong understanding of real-world technology challenges and opportunities. Most DOE-private sector interactions take place in the narrow context of DOE funding opportunities, where DOE and/or the Congress have determined what kinds of activities should be funded. **DOE needs to engage in earlier-stage, collaborative discussions with global energy providers to plan the basic and applied research that could yield the greatest benefits for technology advancement. The challenge is do this without becoming captive to individual corporate interests or promoting corporate welfare.** ***DOE needs to thoughtfully invigorate and expand activities designed to interact with private industry in collaborative, pre-commercial research initiatives.*** **Ultimately, these activities should become a major element of DOE energy research.**

Public-Private partnerships are not new at DOE. Past and current applied-technology partnerships include the Advanced Turbine Program, the Partnership for a Next Generation Vehicle, FreedomCAR, the Advanced Battery Consortium, and a wide range of smaller efforts in the Industrial Technology Programs of the Office of Energy Efficiency and Renewable Energy. Each of these programs has achieved some technical successes, but some have performed better than others.

For example, the Advanced Turbine Systems Program, begun in 1992, brought together the turbine manufacturers, national laboratories, and universities in a decade-long effort to improve the efficiency, reduce the emissions, and lower the operating cost of natural gas power generation turbines, without sacrificing turbine reliability, availability, and maintainability.[5] Although the goals were ambitious, the program met them all, and the innovations that resulted are being incorporated in the commercial gas turbines being fielded today.

Other public-private partnerships have demonstrated some technical successes without achieving commercial success in the timeframes envisioned. This is demonstrably the case in each of the vehicle technology initiatives advanced during the last three administrations, which are among the most high profile public-private partnerships undertaken by DOE.

The Clinton administration's Partnership for a New Generation of Vehicle (PNGV), begun in 1993, had hoped to triple the fuel economy of family sedans (to 80 miles per gallon) within 10 years, while keeping the vehicles affordable and appealing to consumers. Each of the private sector partners in the effort (General Motors, Ford, and Chrysler) developed concept vehicles that were powered by hybrid-electric power trains and small, turbocharged, compression ignition direct-injection (CIDI) diesel engines. In 2001, a National Academy review panel determined that, despite some technical successes, the

[5] For utility-scale turbines, the program's objectives were to achieve: (1) an efficiency of 60 percent on a lower heating value (LHV) basis in combined-cycle mode; (2) NOx emissions less than 10 parts per million by volume (dry basis) at 15-percent oxygen, without external controls; (3) a 10-percent lower cost of electricity; and (4) state-of-the-art reliability, availability, and maintainability (RAM) levels. These were considered at the time to be "leapfrog" performance gains.

production prototypes envisioned by the automakers could not meet cost goals or increasingly stringent emissions requirements. Moreover, consumer tastes had shifted away from family sedans toward sport utility vehicles. The review panel recommended that the program be updated with new "goals and technical targets in the context of current and prospective markets."[6]

Consequently, the Bush administration refashioned the effort into a new partnership with a greater focus on hydrogen fuel cells and electric vehicle drive train components rather than the vehicles themselves; the partnership was also expanded beyond automakers to include fuel providers as well. The FreedomCAR program established specific technical goals and milestones designed to enable participating automakers to make a "commercialization decision" to offer hydrogen fuel cell vehicles in the 2015-2020 timeframe, while laying the groundwork for the hydrogen infrastructure that would be needed to fuel them.

The Obama administration restructured the vehicle technologies programs once again, shifting the focus away from longer-term work on hydrogen fuel cells back to nearer-term plug-in hybrid and battery electric vehicles. The Obama administration initiative aspired to put one million plug-in hybrid electric and battery electric vehicles on the road by 2015.

How have these partnerships performed, and what have they taught us?

- **The affordable 2004 diesel-electric hybrid vehicle envisioned by the PNGV never became a marketplace reality.** The initiative's focus on a particular vehicle type (family sedan) rather than components (batteries, power electronics, and electric motors) was a mistake given the dynamic nature of the light duty vehicle market. Moreover, the 2004 cost goal was unrealistic. Even in the eight years since, automakers have been unable to combine a comparatively high-cost diesel power plant with high-cost hybrid components in a mass-market vehicle at a price point consumers would accept.

- **Hydrogen fuel-cell vehicles have made great strides, but the refueling infrastructure has not.** Several automakers have announced plans to offer hydrogen fuel cell vehicles in the 2015-2020 timeframe envisioned by the Bush administration's FreedomCAR program, but it seems certain that these will be niche vehicles with fairly low production runs given the limited refueling infrastructure that is expected to be available.
    - The Bush initiative did learn some lessons from the PNGV program, however, in focusing on *component* performance and cost (fuel cells, batteries, electric motors, and hydrogen production/delivery infrastructure) rather than on producing a particular kind of vehicle.
    - Also, in contrast to the Obama administration's approach, the Bush initiative's goal was a *commercialization decision*—an assessment of the readiness of a new vehicle option for the marketplace—not a numerical sales target for a designated "winning" product in a future automotive market.

[6] Review of the Research Program of the Partnership for a New Generation of Vehicles: Seventh Report.

- **The Obama administration's effort to put one million electric vehicles on the road by 2015** through a combination of R&D, loan guarantees and tax incentives is, according to most automotive market analysts, **virtually certain to be unsuccessful**, notwithstanding persistently high gasoline prices that would tend to move consumers in that direction.

- **Each of the vehicle technology programs of the Clinton, Bush, and Obama administrations have contributed to technical advances in automotive components** such as the advanced power electronics, batteries, electric motors, and lightweight materials common to all hybrid, plug-in hybrid, and fuel cell vehicles; the cost and reliability of automotive hydrogen fuel cells, and the direct injection and boosting technologies that are now being offered in many internal combustion engine-powered vehicles today. In other words, *technologies arising from all three initiatives are making their way into the marketplace, although not in the form or at the scale originally hoped for*.

- All three of the programs received high-level attention and became presidential initiatives (each was featured in State of the Union speeches) and were part of signature, high-level political messaging efforts. *Consequently, each program was ultimately targeted by the president's political opponents.* In other words, each of the three automotive technology initiatives became politicized. This virtually assured that successive administration would "rebrand" and reorient the program in some manner, usually disrupting technical progress and the work of the industry participants, DOE program managers, and laboratory and university researchers.

All this raises the question: *Does it make sense to pursue grand, transformative energy goals in the context of lavishly-but-unsustainably funded, high-profile presidential initiatives?* While it is understandable why a president might wish to have an Apollo moonshot-style energy project, such efforts are likely to become politicized and partisan, and therefore subject to radical change or elimination with each successive administration.

Moreover, successful energy innovation doesn't fit the Apollo or Manhattan project model. America could build an atomic bomb in 1945 and land a man on the moon in 1969 because the technological products of the Manhattan Project and the Apollo program had only one customer—the federal government—which was willing to pay virtually any price. In contrast, energy (in the form of fuels and electric power) is a widely available commodity that cannot be easily differentiated for consumer tastes. Most consumers are largely indifferent to whether the power is "green" or whether the fuel is derived from a low-carbon process—their focus is price. As a consequence, success in significantly impacting energy extraction, conversion, and use requires the deployment of technology at scale, in complex markets, at low prices, through products and services that are both highly reliable and easily integrated with existing infrastructure. Such an effort generally takes decades.

There are other instances where the politicization of energy innovation has produced a political (or even statutory) goal that was in conflict with contemporary engineering realities. For example, a Republican White House and a Democratic Congress, at a politically opportunistic time characterized by high fuel prices, collaborated to enact an unrealistic Renewable Fuel Standard (RFS) based largely on the

assurances of some well known and well-connected venture capitalists promoting cellulosic ethanol, over the objections of some in the Energy Department who believed that the proposed cellulosic ethanol volumes were wholly unrealistic given the state of conversion technology at the time. Clearly, the RFS cellulosic ethanol goals have proven elusive to date. While the costs of cellulosic ethanol are likely to come down and volumes should eventually rise, we are reminded that the wishful thinking of elected officials cannot trump the practical limits of science and engineering.

These observations are offered to suggest that *the goals and technical milestones of government-assisted energy research and development should be established by scientists and engineers, working in a collaborative manner with private sector energy providers, rather than elected officials and political appointees*. This may admittedly be wishful thinking given the political incentive for political leaders to "act" when voters complain about high energy prices or worry about high emissions. And yet, the lower-profile, lower-cost initiatives (with admittedly lower potential near-term impact) may, by flying a bit below the political radar, be less subject to political interference and earmarked appropriations, and have a better chance to succeed by remaining focused on real engineering goals rather than political ones. This is a problem that cannot be eliminated, but it should be recognized.

The ongoing challenge for DOE is to continue to evaluate and refine its models of public-private collaboration, without becoming captive to individual corporate (or political) interests or allowing DOE programs to become "corporate welfare." These recommendations are meant to assist DOE in structuring more such arrangements.

Recommendations:

- **There should be an emphasis on *structured consortia of private-sector entities* where important collaborative early-stage research can be identified, prioritized, and advanced.**

    - The R&D portfolio review mentioned above should highlight *fundamental scientific challenges* that confront various sectors of the private sector energy enterprise.

    - The approach is to bring together private sector and university partners to undertake *pre-commercial* research activities in a collaborative manner, drawing upon the tools and expertise of DOE national laboratories.

    - All private sector members of the research consortium who share costs would also share in the intellectual property created. Each private sector member, however, would also have the opportunity to improve and enhance the fruits of the research through their own proprietary research and take them to market as appropriate. Eventually, all of the intellectual property created reaches the public domain, but the consortia partners gain a head start and can be "first to market" with any resulting technology.

- **These activities must be cost-shared; participating industry must have "skin in the game" at levels ranging from 20-50 percent of the RDD&D costs, depending on the stage of the technology.**

    - This is not intended to be a handout to industry, or corporate welfare. This is instead an effort to *replicate in some manner the collaborative research environment of the industrial laboratories of the past, but broadening their scope to include potential competitors as collaborators*. This should help encourage the private partners to engage in more long-term, pre-commercial research than they currently engage in, thanks to the power of government to convene partnerships and offer some of the tools and talents of DOE laboratories as part of the effort.

- **Political leaders—despite natural temptations to the contrary—should avoid politicizing these public-private research activities by packaging them as high profile presidential initiatives or opportunities for political messaging.** While there may be times where it is appropriate to do so, such instances should be rare.

- **The emphasis of these public-private collaborations should be on addressing basic scientific challenges and early stage research, development and demonstration rather than the deployment of existing technologies.**

    - These collaborations should be focused on addressing the more fundamental issues rather than the deployment of existing technology. In this context, the Bush administration's FreedomCAR collaboration focused on hydrogen vehicles arguably got some aspects of the program right—the goal was a *commercialization decision*, an assessment of the readiness of a new vehicle option for the marketplace—rather than a delivery date or a numerical sales target for a designated product.

    - Apart from the vehicle technology programs, a number of current public-private collaborations at the Department of Energy are focused on "market development" and "commercialization assistance" rather than technology development. In a constrained fiscal environment, these late-stage commercialization activities should be curtailed in favor of earlier-stage technology development.

Scrutinize "Overhead;" Transfer or Eliminate Technology Deployment and Commercialization Activities that do not Promote Innovation

One of the Department of Energy's dirty little secrets is that *a shockingly small percentage of its funding actually reaches the scientific researcher or engineer's workbench.* Administrative costs, lab overhead, conferences, headquarters activities, support service contracts, and "technology deployment and commercialization" programs divert significant funding that could otherwise be directed toward more meaningful research and development.

Recommendations:

- The General Accounting Office should undertake *a focused audit of DOE funding to determine what percentage of funds appropriated to the applied energy offices is actually used for basic and applied research and development*, as opposed to funds spent on deployment and commercialization activities, administrative and laboratory overhead, program direction, support service contracts, political staff, conferences, travel, and other non-research activities.

    - There may also be excessive opportunities for laboratory management and operations contractors to impose fees on (or skim funding from) managed subcontracts and other transactions. These fees, long regarded as a cost of doing business, need to be fully understood by DOE leadership and explored as a potential savings opportunity.

- *Congress should carefully scrutinize the DOE "deployment and commercialization" program activities that do not meaningfully contribute to the innovation enterprise*. For example:

    - **Weatherization Assistance Grants** ($135.7 million sought in the administration's FY 2013 budget request). These grants support state and local community service organizations working to improve the energy efficiency of low-income homeowners. This program might be more appropriately administered by the Department of Health and Human Services.

    - The **State Energy Program** ($49 million sought in the FY 2013 budget request.) DOE's budget justification documents say the State Energy Program "supports the development and maintenance of state and local renewable energy and energy efficiency programs." In other words, it is a funding pass-through for energy program activities at the state level. Once this funding is divided between the states, territories and the District of Columbia, what is left probably only covers staff and some subsidized showcase "ribbon cutting" at the state level—activities that result in little meaningful technology advancement.

  Programs like these are hugely popular in Congress because they fund state and local activities and events that are often designed to attract political interest, so we harbor no illusion that our

proposal will speed their elimination or transfer to other agencies. But having made recommendations to improve the performance of DOE's energy innovation activities, we feel obliged to highlight some of the programs that compete against those activities for scarce discretionary funding.

A New Approach to International Innovation Activities

CHALLENGE: DOE's international activities are of limited value, despite the enormous opportunity to advance innovation in growing global energy markets. DOE has signed literally hundreds of bilateral and multilateral agreements with other countries and international agencies designed to foster cooperative research and development, but these agreements are generally more ceremonial than substantive. Most are opportunistically conceived and signed when the Secretary of Energy is visiting a foreign nation, or when a foreign Energy Minister is visiting DOE. **Most such agreements bear little fruit and are quickly forgotten, and yet they are currently a major activity of the DOE International Programs Office.**

Most energy system expansion is occurring in the developing world. Nations such as China are leapfrogging the United States and Europe by developing or procuring the latest technology in power generation, transmission, and utilization wherever possible. In many respects, *these nations are becoming the test beds for new energy technologies and business models*, as expanding and underserved populations clamor for increased energy services. This is why, for instance, Bill Gates is engaged in discussions with China and South Korea to co-develop and demonstrate a next-generation, inherently safe "travelling wave" reactor fueled by depleted uranium. Due to a host of factors, it is more likely that such a reactor could be developed, financed, licensed, and built in China and/or South Korea rather than the United States.

America cannot depend solely on laboratory and pilot scale work to foster leadership in energy technologies, since a tremendous amount of innovation occurs in the process of building and deploying new technology at commercial scale. And DOE cannot, and should not, attempt to manage research, development, and demonstration of new energy technologies in foreign nations, or subsidize such investments. But at the same time, DOE should not create a host of unfulfilled expectations by entering into bilateral energy R&D agreements that provide little more than a photo opportunity for a U.S. Energy Secretary or a foreign Energy Minister.

Instead, DOE must recognize that U.S. energy companies and U.S. technology developers can play a pivotal role as developers, suppliers, and service vendors in developing nation energy technology deployments. In so doing, they will be competing with global vendors and moving technology and know-how from the laboratory to the field—a key component of innovation. Consequently, ***the primary focus of DOE's International activities should be to promote, facilitate, and host opportunities between U.S. businesses and rapidly growing developing world energy markets*.** Consider these examples:

- Quite often, international cooperative technology development/deployment activities that are advancing without DOE participation need little more than awareness and acknowledgement on DOE's part—not public dollars—to get the project over the finish line. For example, a U.S. business and a State Owned Chinese entity may be jointly funding activities to use U.S. technologies and components made in America to convert Chinese coal to synthetic natural gas. But because the Chinese entity is government owned, the Chinese government will look for acknowledgement from the U.S. government—the Department of Energy—that the project has

merit in the context of U.S.-Chinese interests. That may be all that is necessary on the part of DOE.

- U.S. companies, in an effort to bring new technologies to market, will often seek a government subsidy or a loan guarantee in an effort to "push" a technology into a U.S. market that might not really want it or be ready for it. **It may be that the natural market for the new technology is not in the U.S. but abroad.** Consider the following hypothetical example, suggested by Clayton Christensen's book, *The Innovator's Dilemma*:

    - A U.S. innovator is working to develop and market a small electric "city car," but it is impossible to commercialize because the vehicle doesn't meet U.S. consumer expectations or market demands. *But the car might be ideal for Bangkok*, where the government of Thailand is trying to solve a chronic congestion/air pollution challenge and thus might be willing to host a pilot program or make a fleet purchase.

    - DOE's International Program office can have a real impact if it recognizes the opportunity to act as the "matchmaker" between the U.S. company and the foreign government.

    - While the U.S. would not be the first to deploy the innovative electric vehicles in this example, the U.S. company would nevertheless be *first to market*, creating jobs and exports in the near term while establishing its base in the market and developing knowledge and capital that are necessary to produce new technologies and models that might satisfy U.S. markets and consumer demand in the long term.

    For DOE to effectively play the role of "matchmaker," it would have to develop new skills and capacity and prioritize these kinds of real-world, real-market activities that are focused on the needs and capabilities of U.S. manufacturers rather than DOE itself.

These are just a few examples to illustrate the ways in which DOE should shift its international focus from nearly meaningless bilateral and multinational research and development agreements to an entirely different set of more diverse, more challenging, and more meaningful innovation activities.

The Enduring Problem of Large-Scale Demonstrations

CHALLENGE: DOE has proven itself to be virtually incapable of executing commercial scale "first-of-a-kind" (FOAK) technology demonstrations. FutureGen, a coal-fuel power plant intended to demonstrate large-scale, high-percentage carbon capture and storage, is just the most recent failure. ***New institutional arrangements and partnership models are necessary.***

Nearly all federal projects, including many cost-shared demonstrations using appropriated dollars, are governed by a host of federal requirements that add significant cost and administrative burdens to complex, multi-year construction projects. In addition, year-to-year fluctuations in funding levels resulting from relevant (or irrelevant) political factors, or the inability of the Congress to enact appropriations bills in a timely manner, generally result in a federal project's annual funding level falling below project managers' optimal funding/construction path. As a result, it is all-but guaranteed that *a federal project will take longer to construct, and cost significantly more, than a comparable private or commercial project*.

Moreover, there is tremendous uncertainty in any FOAK project—some projects *will* fail. Because a high profile failure occurring on the watch of one political party becomes a potentially potent messaging opportunity for the other, federal project managers are likely to aim low and do what is necessary to avoid obvious failure. The true culture of innovation is quite different—to aim high, fail often (but quickly), and remain sufficiently agile to correct mistakes and keep moving forward.

FutureGen was launched in 2003; originally it was scheduled to produce an operational Integrated Gasification Combined Cycle (IGCC) coal-fueled power plant with carbon capture and sequestration (CCS) by 2012. The project has been cancelled, reconstituted, and reconfigured, but construction has never begun.

Meanwhile, the private sector, with DOE assistance (as differentiated from DOE leadership and direction), is moving ahead with commercial-scale CCS demonstrations. The Southern Company's Kemper project in Mississippi, a 582-MW coal plant with 65-percent carbon removal, is now under construction. In addition, Summit Power's Texas Clean Energy Project, a 245-MW project with 90-percent carbon removal, is expected to break ground this summer. Each of these projects will earn revenue by not only selling their electricity and other products (urea in the case of the Texas project), but by selling the separated CO_2 for enhanced oil recovery (EOR).

Recommendations:

- **Construction of large-scale, first-of-a-kind (FOAK) commercial technology demonstrations such as FutureGen should be undertaken by outside private sector consortia, assisted, as necessary, by alternative sources of patient capital, federal tax holidays, targeted grants or special funding arrangements**. We cannot recommend a single, specific approach that should be used, since various approaches may be suitable for different technologies and circumstances. But we

note that others, recognizing the difficulty that DOE has experienced with large commercial-scale demonstrations, have suggested the following:

- The Carbon Capture and Storage Early Deployment Act, introduced by former Representative Rick Boucher (D-VA), envisioned an *industry-funded and industry-managed organization to finance the development and demonstration of carbon capture and storage (CCS) technology,* funded through a fee on retail electricity bills;

- The American Energy Innovation Council (AEIC) suggested the creation of a New Energy Challenge Program, established as *a publically-owned private corporation operating outside of the federal government, using a blend of public and private funding to build FOAK large-scale energy demonstration plants* including 4th Generation Nuclear and CCS projects.

Each of these proposals envisioned a tranche of funding, either derived from ratepayers or taxpayers, that enjoyed some level of protection against future funding raids emanating from Congress or the administration. The fact that the more successful large-scale DOE IGCC demonstrations of the past were also beneficiaries of a funding tranche (in the form of advance appropriations) and protection against funding diversions (due to the efforts of a powerful and enduring advocate in the personage of the late U.S. Senator Robert C. Byrd) is instructive. The essential point is that DOE should not attempt to *lead* commercial demonstrations in the absence of similar conditions; it should instead consider ways that it might *assist* private entities as they conduct relevant commercial-scale demonstrations.

Concluding Observations

Reform of the Department of Energy will be a long-term effort that cannot be completed during a single presidential term or administration—but it must begin now. The twenty or so recommendations in this paper offer a plausible path forward.

We cannot recreate the large corporate R&D laboratories of the 1950's and 1960's, nor should we attempt to do so in a government agency. But we can and should leverage the power of the government to convene collaborative partnerships, comprised of private sector participants in the energy marketplace along with researchers in universities and national laboratories, in concerted efforts to tackle energy innovation challenges. This will require a profoundly different institutional culture than the inward-looking, secretive, and risk-averse approach that DOE and its predecessors nurtured for the design, construction, and testing of nuclear weapons and naval reactors.

Thus, the reforms required at DOE must reach deeper than the classic government reorganization. While an attached appendix provides organization charts that display the current structure and how it might change if these recommendations were adopted, we must stress that "moving the boxes" will not be enough. The process of reform will require bipartisan support and understanding, patient and inspired departmental leadership, the continuing recruitment and development of talented energy and science program managers, the willingness to attempt bold new operational approaches, and a deep understanding of emerging opportunities in the energy marketplace.

We also appreciate the fact that there are issues that we have not addressed in this paper that are worthy of discussion going forward. These include:

- What is the appropriate role of DOE in deploying new technologies? Is a government-run loan guarantee program necessary for large capital-intensive projects employing innovative new technology? If so, is DOE the right agency to run it?

- The U.S. has generally used tax policy (production tax credits, depreciation, etc.) to incentivize the deployment of new energy technology and/or the turnover of capital stock. What are the successes and shortcomings of this approach *in promoting innovation*?

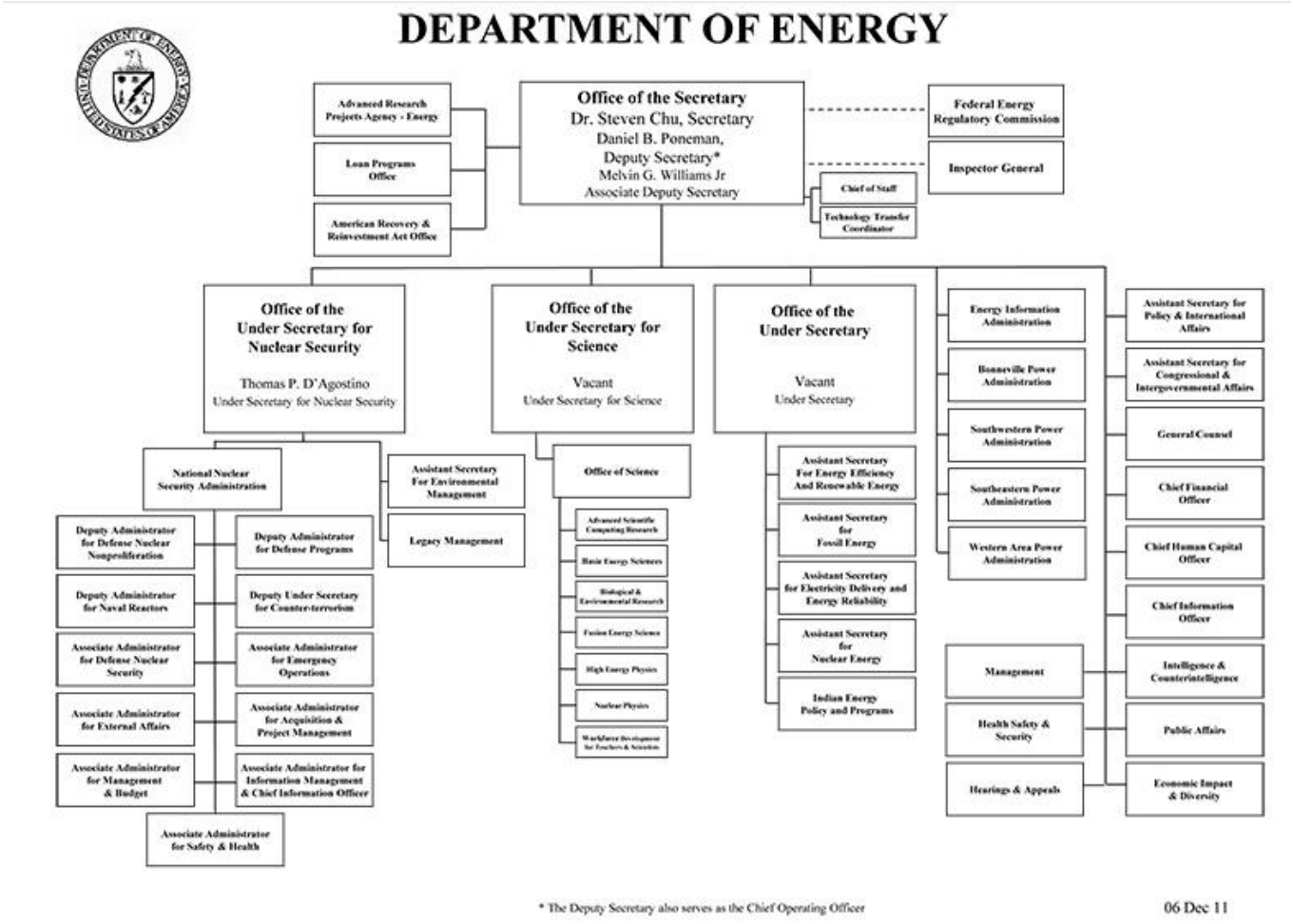
- What have we learned from the efforts of the Department of Defense in procuring new advanced technologies, and are there lessons for DOE?

- How can we best promote a healthy level of alternative and competing analysis—not only with respect to energy policy options, but also in terms of the evaluation of DOE program effectiveness?

While these questions must remain beyond the scope of this paper for now, we hope this set of recommendations may serve to spark a careful examination of both the issues we have explored here and those we could not.

Appendix: Organizational Charts

Current Organizational Chart



New (Notional) Organizational Chart