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TECHNOLOGY TRANSITION INITIATIVES AT THE U.S. DEPARTMENT OF ENERGY

A Report to NEDO

David W. Cheney

George R. Heaton, Jr.

Christopher T. Hill

Patrick H. Windham

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PREFACE

The study underlying this report was commissioned by the Washington, D.C., office of Japan's New Energy and Industrial Technology Development Organization (NEDO).

The opinions expressed in this report do not necessarily reflect the views of NEDO or of other institutions with which the authors are affiliated.

David W. Cheney*
Silver Spring, MD
david.cheney@technopoli.net

George R. Heaton, Jr.
Boston, MA
george.heaton@technopoli.net

Christopher T. Hill
Knoxville, TN
christopher.hill@technopoli.net

Patrick Windham
Arlington, VA
patrick.windham@technopoli.net

*Managing Partner, Technology Policy International, LLC

ABOUT THE AUTHORS

David W. Cheney is a consultant and the former Director of the Center for Science, Technology and Economic Development at SRI International, where his work focused on planning and evaluating science, technology, and innovation programs and institutions, primarily in the United States and Middle East. He is also an adjunct professor at George Mason University. Before joining SRI in 1998, he was a senior executive in the U.S. Department of Energy, serving as director of the Secretary of Energy Advisory Board and advisor to the Deputy Secretary on industrial partnerships and national laboratories. He previously was a senior associate with the Council on Competitiveness, and an analyst with the Congressional Research Service. He has also held positions with the Internet Policy Institute, the Optoelectronics Industry Development Association, the Competitiveness Policy Council, and the Institute for Policy Science at Saitama University in Japan. He has a PhD in public policy from George Mason University, a MS in Technology and Policy from MIT and a BS in Geology & Biology from Brown University.

George R. Heaton, Jr. is a member of the faculty at the Worcester Polytechnic Institute in Massachusetts and an independent consultant in science and technology policy, environmental policy and law. Trained as a lawyer, Mr. Heaton has been on the faculty of the Massachusetts Institute of Technology, and has worked widely for public and private technical and policy institutions in the U.S. and abroad. Maintaining extensive professional and personal relations in Japan, Mr. Heaton was a Visiting Professor at Saitama University in 1986-87 and the First Foreign Scholar of the Ministry of Health and Welfare in 1989-90.

Christopher T. Hill is Professor Emeritus of Public Policy and former Vice Provost for Research at George Mason University in Fairfax, Virginia. He was a Senior Fellow at SRI International from 2011 to early 2016. After earning three degrees in chemical engineering and practicing in that field at Uniroyal Corporation and Washington University in St. Louis, he has devoted more than four decades to practice, research and teaching in science and technology policy, including service at MIT, the Office of Technology Assessment, the Congressional Research Service, the National Academy of Engineering and the RAND Critical Technologies Institute.

Patrick H. Windham is a consultant and university lecturer on science and technology policy. From 1999 to 2012 was a Lecturer in the Public Policy Program at Stanford University and more recently has taught at the University of California's Washington, DC, center and the University of Maryland. From 1984 until 1997 he served as a Senior

Professional Staff Member for the Subcommittee on Science, Technology, and Space of the Committee on Commerce, Science, and Transportation, United States Senate. He helped Senators oversee and draft legislation for several major civilian science and technology agencies and focused particularly on issues of science, technology, and U.S. industrial competitiveness. Mr. Windham received an A.B. from Stanford University and a Master of Public Policy degree from the University of California at Berkeley. He currently lives in Arlington, Virginia.

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TECHNOLOGY TRANSITION INITIATIVES AT THE U.S. DEPARTMENT OF ENERGY

INTRODUCTION

On February 11, 2015, U.S. Secretary of Energy Ernest Moniz announced the creation of an Office of Technology Transitions (OTT) "to help expand the commercial impact of the Department of Energy's (DOE) research." [1]

The creation of OTT is one part of recent efforts by both the Obama Administration and members of Congress to increase the commercial and economic benefits of DOE's research, technology, and facilities. This paper examines why DOE established OTT, what role it is playing in the Department's overall technology transition efforts, and what results or outcomes we might expect.

To set the stage for the discussion of OTT, this report first provides a brief history of DOE's research and development (R&D) and its laboratories. That history helps explain the opportunities and challenges associated with trying to make DOE's research, technology, and facilities more useful to commercial industry.

In particular, this history will emphasize three aspects of the Department of Energy and its laboratories: the diverse missions and activities of different parts of DOE, the challenges and opportunities associated with trying to facilitate commercial access to the laboratories and generate commercial benefits, and the challenges of coordinating technology transfer in such a large, diverse department.

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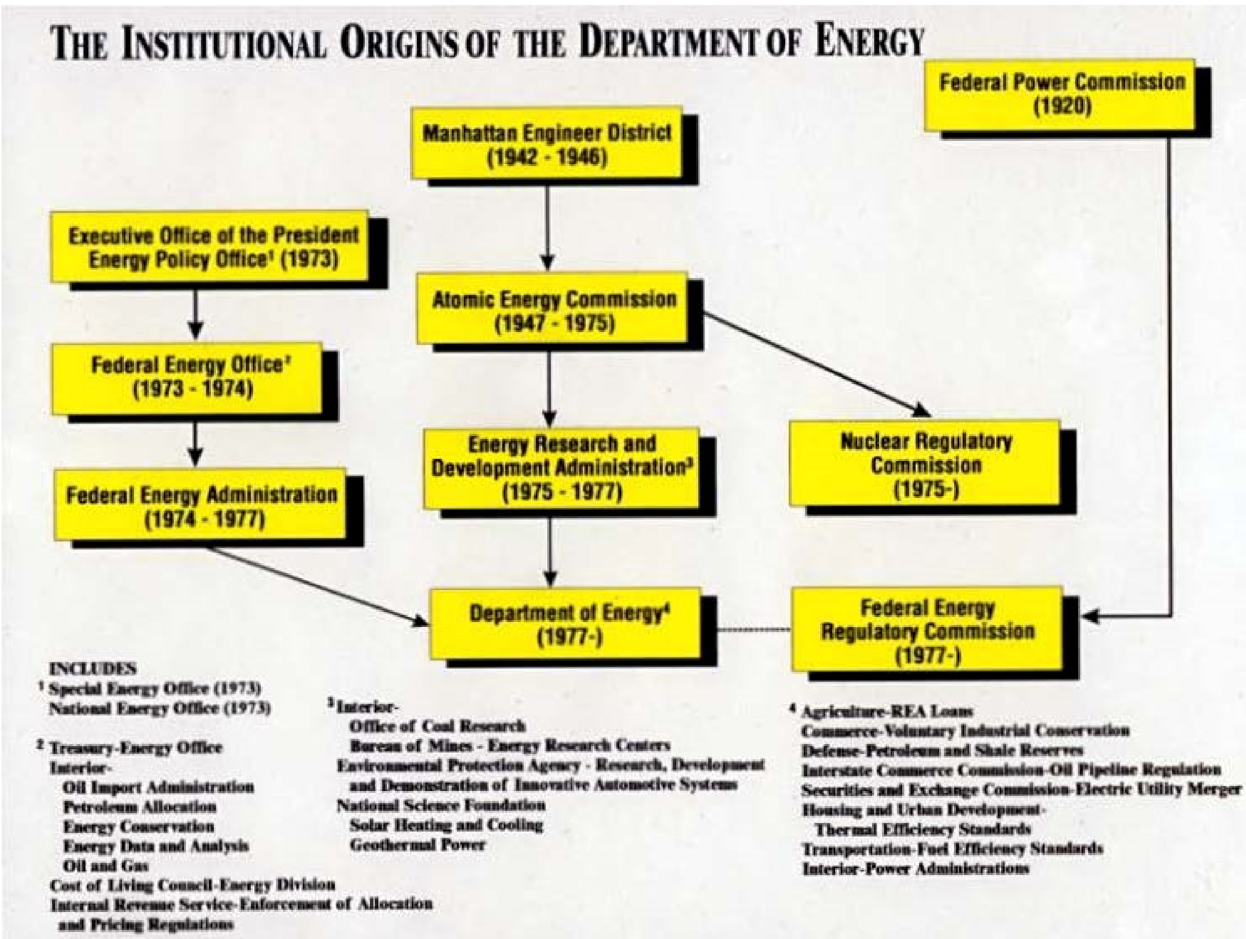
[1] Department of Energy, "Energy Department Announces New Office of Technology Transitions," February 11, 2015, http://energy.gov/articles/energy-department-announces-new-office-technology-transitions.

HISTORICAL CONTEXT OF THE DEPARTMENT OF ENERGY AND ITS LABORATORIES

FORMATION OF THE DEPARTMENT OF ENERGY

The United States Department of Energy has a complex ancestry. The chart below shows the institutional origins of the Department. We offer here a somewhat stylized and simplified version of the history of the Department, a history which is much more complex than we can address in a few paragraphs.[2]



Source: Department of Energy

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[2] A Department of Energy web site provides a useful brief summary history of the Department and its predecessor agencies. See, "DOE History Timeline" at: http://energy.gov/management/office-management/operational-management/history/doe-history-timeline

The Department (hereinafter "DOE") was established by the Department of Energy Organization Act of 1977, which was adopted in large part as a comprehensive response to the challenges to the nation posed by the OPEC oil embargo of 1973/74 and the associated "energy crisis." The newly created DOE was assembled from a variety of pre-existing agencies and bureaus to provide a focus on research, development, and demonstration of new and improved energy technologies. DOE took over the energy R&D responsibilities of the Energy Research and Development Administration (ERDA), which was abolished by the 1977 Act. Less well-recognized at the time in the public debate over the energy crisis was that DOE also assumed ERDA's responsibility for nuclear weapons R&D. DOE at its founding also assumed responsibility for various energy planning and coordination activities that had been set up in the White House as an immediate response to the oil embargo.

Just a few years earlier—in 1974—Congress had created the Energy Research and Development Administration in a government reorganization that split the pre-existing Atomic Energy Commission (AEC) into ERDA and the Nuclear Regulatory Commission (NRC). ERDA took over the AEC's nuclear energy research, the energy and closely related materials and minerals R&D from the pre-existing Bureau of Mines in the Department of the Interior, and lesser elements of several other departments and agencies. The NRC was given the responsibility for regulating, but not promoting civilian nuclear energy.

The Atomic Energy Commission, in turn, was established in 1947 to assume the atomic weapons responsibilities of World War II's Manhattan District of the Army Corps of Engineers and the Office of Scientific Research and Development. The AEC was seen as a mechanism to establish civilian control over nuclear weapons, which had previously been under military supervision. In addition, the AEC was charged with developing technology for, promoting investment in, and regulating civilian nuclear power generation and other peaceful uses of atomic energy.

It is important to note that the history of Federal involvement in energy-related R&D did not begin with the Manhattan project. Elements of the Bureau of Mines date back to just after the turn of the 20th century, and the Federal government had made modest investments in nuclear and high energy physics research in the 1930s that led, among other things, to the establishment of what became known later as the Lawrence Berkeley National Laboratory.

THE DOE LABORATORIES

To conduct the research, development, and testing of nuclear weapons during World War II, the Manhattan Project set up a number of highly specialized and secret laboratories and manufacturing facilities. These laboratories and manufacturing sites developed methods to produce and recover highly enriched fissionable uranium and plutonium, to design and manufacture the various elements of nuclear fission devices (bombs), and to test concepts and bomb designs. These laboratories and facilities were generally put in remote locations and/or near important sources of raw materials or electricity. In some cases, they were located near universities that could offer scientific and technical expertise to the war-time effort. In the immediate post-war era, an additional laboratory was created to do R&D on advanced nuclear weapons and on nuclear fusion, leading to the hydrogen bomb.

Today three of these laboratories are known colloquially as the "weapons labs:" Los Alamos National Laboratory, Sandia National Laboratories, and Lawrence Livermore National Laboratory. Not generally thought of today as weapons labs, nevertheless the war effort also created the Oak Ridge National Laboratory, the Argonne National Laboratory, the Pacific Northwest National Laboratory, and what became Lawrence Berkeley National Laboratory. Idaho

In subsequent years, the AEC (and later, DOE) expanded its array of laboratories to include the Brookhaven National Laboratory, the Fermi National Laboratory, the Stanford Linear Accelerator Center (now known as SLAC National Laboratory), and the Thomas Jefferson National Laboratory. These centers conduct R&D in the fields of high energy and nuclear physics. Each of these laboratories, as well as the Lawrence Berkeley National Laboratory and the Argonne National Laboratory, is built around a high energy particle accelerator and storage ring that can be used not only to study the behavior of subatomic particles under very high energy collisions but which also produce very high intensity beams of electromagnetic radiation in various frequency ranges that can serve as very versatile "microscopes" for studying the properties of all sorts of materials of scientific and commercial interest. These large "user facilities" are open for use by the scientific community for research that will be published in the public domain, and can also be hired by industry for proprietary research.

When ERDA was formed, these laboratories were carried over essentially unchanged from the AEC to ERDA. There was little formal change in the system of laboratories during ERDA's brief life, although they were much more focused on addressing problems in energy production and consumption generally than they had been prior to 1974.

When the DOE was formed in 1977, it took over responsibility for all of the laboratories that had belonged to ERDA, including, as mentioned earlier, several laboratories that had belonged to the Bureau of Mines in the Department of the Interior and had been transferred to ERDA in 1975.

By and large the Bureau of Mines laboratories were decades older and much closer to commercial energy sectors such as the petroleum production and coal mining industries than the other ERDA labs had been. As such they became the core laboratories through which DOE conducted energy research of industrial interest, other than atomic energy research, and through which DOE managed grants and contracts to academia and industry in the energy field, especially in fossil fuels and energy conservation. In the early years of the DOE, two of the former Bureau of Mines laboratories were spun off to non-Federal owners and the other Bureau of Mines laboratories were reorganized, resulting in today's National Energy Technology Laboratory headquartered in Pittsburgh, Pennsylvania, with branch operations in a half dozen other locations.

Just a few months after the establishment of ERDA, responding to Congressional authorization, the Department established the Solar Energy Research Institute (SERI), which was later renamed and became today's National Renewable Energy Laboratory (NREL). As its names suggest, NREL is the lead laboratory for R&D on solar and other renewable energy technologies, with work in energy conservation as well.

At present DOE has the seventeen major laboratories listed in Table 1 and shown in the map following the table.[3] Some of the laboratories operate in more than one location. And, it should be clear that all of them are, in fact, composite laboratory organizations that each have many separate laboratory facilities as a working scientific or engineering researcher would understand the word, laboratory. In addition to these laboratories, DOE maintains numerous smaller laboratories around the country.

Table 1 Major DOE Laboratories with Their Locations and Dates of Establishment

- National Energy Technology Laboratory

  at Pittsburgh, Pennsylvania (1910)

  at Morgantown, West Virginia (1946)

  at Sugar Land, Texas (2000)

  at Fairbanks, Alaska (2001)

  at Albany, Oregon (2005)

- Lawrence Berkeley National Laboratory at Berkeley, California (1931)

- Los Alamos National Laboratory at Los Alamos, New Mexico (1943)

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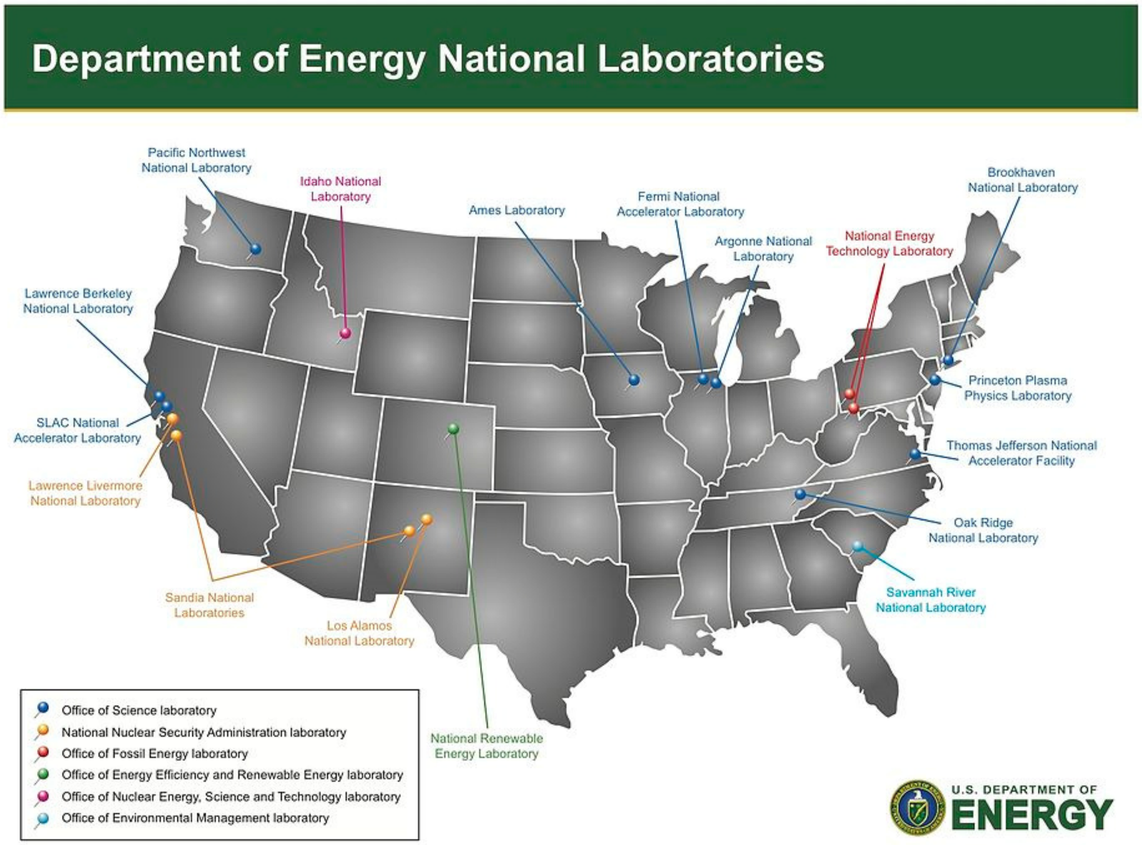
[3] Table 1 and the map of DOE National Laboratories are copied from a Wikipedia article at: https://en.wikipedia.org/wiki/United_States_Department_of_Energy_national_laboratories.

- Oak Ridge National Laboratory at Oak Ridge, Tennessee (1943)
- Argonne National Laboratory at DuPage County, Illinois (1946)
- Ames Laboratory at Ames, Iowa (1947)
- Brookhaven National Laboratory at Upton, New York (1947)
- Sandia National Laboratories at Albuquerque, New Mexico and Livermore, California (1948)
- Idaho National Laboratory between Arco and Idaho Falls, Idaho (1949)
- Princeton Plasma Physics Laboratory at Princeton, New Jersey (1951)
- Lawrence Livermore National Laboratory at Livermore, California (1952)
- Savannah River National Laboratory at Aiken, South Carolina (1952)
- SLAC National Accelerator Laboratory at Menlo Park, California (1962)
- Pacific Northwest National Laboratory at Richland, Washington (1965)
- Fermi National Accelerator Laboratory at Batavia, Illinois (1967)
- National Renewable Energy Laboratory at Golden, Colorado (1977)
- Thomas Jefferson National Accelerator Facility at Newport News, Virginia (1984)



One important point is that the seventeen major DOE laboratories have quite different histories, different core missions, different sets of special capabilities and equipment, and different cultures and ways of doing business. Some are devoted to the most esoteric of fundamental research into the nature of matter and energy, while others focus more on practical applied research and development and demonstration projects related to the production and use of energy in the economy. Still other laboratories continue to focus on nuclear weapons R&D and on maintenance and improvement of weapons in the national stockpile—so called “stockpile stewardship.” At the same time, the boundaries between the technical and scientific capabilities of the various laboratories are not sharp. One can easily find energy conservation studies going on in a weapons lab like Los Alamos and applied biological structures research going on in a lab whose main purpose is to understand the structure of the atomic nucleus. Another important point is that the scope of scientific and technical inquiry conducted in and supported by the laboratories is extremely broad. Advanced materials are ubiquitous in energy systems, so the labs collectively have deep capabilities in ceramics, metallurgy, solid state physics, inorganic chemistry and the like, including unique facilities for examining the structure and properties of materials of all kinds. Because computer simulations are absolutely essential to design of weapons, to modeling climate change, and to understanding the behavior of the national electricity grid, among other energy topics, the DOE laboratories own some of the world's largest and fastest supercomputers and have deep skills in computational sciences generally. Engagement in the life sciences in DOE dates back to the early days of the nuclear weapons and nuclear energy programs when scientists needed to understand the effects, intended and otherwise, of nuclear and other ionizing radiation on living things, including people. Early on it was recognized that radiation can act on living things at the genetic level so DOE has had a high level of expertise in molecular biology, genetics and genomics. One could list many other fields in which DOE does and/or supports some of the world's most cutting edge research.

FUNDING R&D AT THE DOE LABORATORIES

Funding for R&D at the DOE laboratories comes to them from different DOE programs as defined in the Department's annual appropriations from Congress. This funding is structured into large numbers of discrete projects supported by the diverse DOE programs. Work at the laboratories has to be consistent with the purpose of the specific funds for that work. So, for example, if a new technology that is developed by a science lab or a nuclear weapons lab has potential for an energy application, it can usually only be developed further for those applications if additional funding is made available from an energy program. And, typically, there are no available DOE funds for further development of the technology for commercial purposes that are outside of the Department's mission, such as general manufacturing or health care.

Some of the DOE laboratories are largely funded by a single program. Other large laboratories are considered to be "multi-program" laboratories and receive significant funds from many programs. Laboratories can also receive funds from outside of DOE, to do projects denoted as "work for others". Such work can be supported by funds originating in another Federal department or agency, or from industry.

Despite the importance given to technology transfer and commercialization at DOE by policymakers, industry and state and local interests, the fact is that there are only very limited funds in the entire DOE system to support such activities, except to the extent that the activities support one of DOE's missions. It may be useful to give a few examples of the kinds of activities that DOE can and cannot fund.

DOE can support research and development, and industrial collaborations, for a wide range of energy technologies, including energy efficiency measures. So it can support work to improve the energy efficiency of automobiles or steel production. But it generally cannot support work to make product improvements or non-energy-related productivity improvements in those industries. DOE can also fund work with industry to support its other missions. The labs have also worked extensively with supercomputer manufacturers to develop and to procure the most advanced computers needed for its weapons programs, and have worked with other firms to develop technologies to clean up radioactive and hazardous wastes from its nuclear production sites. The laboratories can also collaborate with industry on a cost-shared basis on R&D projects that have an industrial benefit but also benefit the Department's missions. For example, the labs can use DOE funds to support laboratory activities in research collaborations with auto manufacturers on computer simulations, because the joint work benefits DOE by helping to strengthen the simulation capabilities needed for the nuclear weapons programs.

MANAGING AND OPERATING THE DOE LABORATORIES

Prior to the onset of World War II, the United States government had very limited capacity to fund or conduct R&D other than in agriculture, geological sciences, weights and measures, and some applied social sciences. It was recognized early that to reach the very ambitious goals of the Manhattan Project, the Federal government would need to enter into partnerships with organizations that had had experience in conducting research at large scale and that already employed scientists and engineers with the requisite backgrounds in science and engineering needed to pursue the Project's objectives successfully.

To this end, the government entered into contracts with major research universities and private companies to design, build, and operate both the R&D laboratories and the production facilities needed to conduct the work of the Manhattan Project. The University of California agreed to operate the Los Alamos National Laboratory, the University of Chicago operated what became the Argonne National Laboratory, the Bell Telephone Company agreed to operate what became the Sandia National Laboratories, and so on. These arrangements set the stage for the government-owned, contractor-operated laboratories—the so-called "GOCO" laboratories.[4] These laboratories carried out programs of R&D laid down by their government overseers following policies and procedures set forth in their management and operating agreements. The government paid for the research and owned the results of that research in the form of patents, trade secrets, classified information, and copyrights per the terms of the contracts. In the early days of such labs, companies often agreed to manage the labs under terms in which the government paid all of the costs, plus one dollar per year as a management fee. The one-

[4] For a more detailed discussion of the GOCO and contrasting Government-Owned, Government Operated, or "GOGO" laboratories, see: "Institutions to Perform Government Funded R&D, TPI report to NEDO, September 2015. On line at: http://www.technopoli.net/yahoo_site_admin1/assets/docs/Government_RD_Institutions.4184933.pdf

dollar fee was an implicit acknowledgement that in time of war, everyone needed to contribute to the war effort and that a large profit on lab operations would have been unseemly.

By contrast, the energy and mineral resource laboratories belonging to the Bureau of Mines had, since inception, been managed as GOGOs— "government owned, government operated" organizations. Unlike the employees of the GOCOS, who worked for the company or university that operated the GOCO lab under contract, the employees of the Bureau of Mines GOGOs were government employees, subject to all the employment rules of the Federal Civil Service. Even today, the National Energy Technology Laboratory (the modern version of the Bureau of Mines laboratories) is operated by DOE as a GOGO.

Technology Transfer and Technology Transition at the DOE Laboratories

As we have seen, the primary mission of most DOE laboratories is *not* to help American industry. The main job of the weapons laboratories is to protect national security, and the science laboratories focus on basic scientific research. NREL and the National Energy Technology Laboratory do work closely with companies, but their mission focuses primarily on energy and not on general industrial technology. Nonetheless, these large and diverse laboratories do have world-class technologies, expertise, and facilities, and the U.S. Congress and presidents have directed them to transfer technology to companies, when possible and appropriate.

So is technology transfer from DOE laboratories easy or difficult? This section of the report discusses the complex challenges the laboratories face as they try to transfer technology to U.S. industry.

The DOE laboratories as a group face a highly complex and differentiated set of technology transition and technology transfer challenges, practical, legal/administrative, and political. In some cases, developing and transferring technologies to a defined set of "clients" is a core mission of the institution. In other cases, a laboratory may accept funding from another part of DOE or from another federal agency and therefore will provide services to these additional clients. In still other cases, doing very fundamental studies of the nature of the universe is the core mission, and any technologies that are developed are viewed as purely incidental to that mission, even though they may turn out to have considerable commercial interest. Here are some of the diverse kinds of challenges they face:

- The weapons laboratories necessarily operate in a highly classified environment in which what they do, who is doing it, and why they are doing it may all be classified. Their facilities are generally off limits to anyone who does not have the required security clearance and a bona fide reason for being there. Yet these labs have capabilities in a wide range of scientific and technical fields that could be put to use for non-weapons, non-classified purposes and, in fact, they are encouraged to seek ways to transfer their technologies to industry where possible, but generally cannot use defense-related funding to further develop technologies for commercial purposes.

- The basic science laboratories, by contrast, operate in a more open way, with physical security being limited to ordinary industrial practice to protect valuable physical facilities against theft or trespass and to ensure public safety. Visitors are identified and screened, but need not have security clearances. On the other hand, their capabilities and facilities are often highly specialized, and that can limit their abilities to provide useful technologies to those outside the highly specialized fields in which they do research.

- The laboratories focused on developing energy and energy-related technologies of interest to industry typically face the same technology “hand-off” problems associated with any separate R&D organization serving a company; that is, what the researchers come up with may or may not be perceived by potential users as offering capabilities and value that those users need. Conversely, when they do come up with a new development that companies may want to exploit commercially, then the labs have a different sort of problem—deciding whether and how to transfer the technology to single firms, to a group of competitor firms, or to the general public.

- As discussed below, the GOGO and GOCO laboratories operate under different legal and administrative regimes regarding ownership, benefit, and transfer of intellectual property they develop. Furthermore, the different GOCO laboratories have different histories and are operated under different contracts by different sorts of entities. Some are operated by single universities or companies, others by consortia of universities, and still others by collaborations of universities and companies. Each arrangement creates different environments of incentives for, and barriers to, technology transfer.

- The political expectations for technology transition and for formal technology transfer activities have not been consistent over the decades of life of the laboratories. Prior to the passage of the Stevenson-Wydler Technology Innovation Act of 1980 and the Bayh-Dole Act of that same year, the laboratories did not operate under consistent policy guidance regarding technology transfer. In general, and with exceptions, they were expected to make any new technologies of commercial interest that they developed freely available to any and all users. When such technologies were patented, they were to be freely licensed on a non-exclusive, non-fee-bearing license basis. The underlying concept was that technologies developed with public funds should belong to everyone and be used by anyone who wanted to use them. The Bayh-Dole Act created a framework within which universities and non-profit organizations that received government funds to support research could take title to, and enjoy financial benefit from, the use or licensing out of technologies that were developed using those funds. However, application of this principle to the GOCO laboratories remained undeveloped and unclear for several years.

- Congress passed the Federal Technology Transfer Act of 1986, which was an amendment to Stevenson-Wydler, to clarify that transfer of technology developed in federal laboratories was a legitimate and important mission of those labs, regardless of their other core mission or missions. Under this act, Federal laboratories could enter into licensing agreements with companies and could enter into joint R&D projects with companies known as Cooperative Research and Development Agreements (CRADAs) that would enable the private partners to hold title to the resulting technologies. Unfortunately, this act did not apply clearly to the DOE GOCO laboratories, and further amendments, known as the National Laboratory Technology Transfer Act, were adopted in 1989 to extend the privileges of the Federal Technology Transfer Act to the GOCO labs and their Management and Operating contractors.

- Owing to the diversity of M&O contracts and contractor circumstances, among other reasons, the GOCO labs to this day do not operate uniformly with respect to technology transfer and transition. Each lab has its own intellectual property policy and procedures and its own staff of technology transfer experts and legal advisors who interpret their authorities and responsibilities somewhat differently. From the point of view of potential commercial users of technologies developed in Federal laboratories, this diversity of implementation of technology transfer practices comes as an unwelcome and expensive surprise. From the user perspective, it might appear obvious that all government labs should follow the same rules and procedures; the fact that they do not is itself a barrier to technology transfer and transition.

- While companies can pay for work at the laboratories that makes use of their unique facilities and specialized staff, companies must pay for the full costs of the work (including overhead rates that reflect the cost of facilities and administration), and the work at the laboratory must generally be paid for in advance. This is a barrier to all companies using the laboratories, and especially to small businesses.

- Matching lab capabilities to commercial needs and opportunities can be a daunting challenge. The set of DOE laboratories, as a whole, is an enormous enterprise that employs many tens of thousands of experts and spends tens of billions of dollars each year. To outsiders, such as companies looking for assistance or partnership around particular technologies or looking for solutions to technical problems, it can be a Herculean task to locate the "right" experts or right capabilities within the seventeen laboratories who are willing, able, and ready to help. While mission-specific capabilities may be somewhat straightforward to locate (for example, a manufacturer of solar panels would probably know to go to the National Renewable Energy Laboratory for help), it can be much more challenging to locate capabilities that do not flow obviously from missions (for example, an aircraft parts manufacturer needing advice on 3-D printing might not think it should be obvious that the Oak Ridge National Laboratory is, in fact, a leader in large-scale 3-D printing technology.)

- Political support for the transfer of new technologies developed at DOE laboratories (and in other agencies for that matter) has been highly variable since the push to commercialize federal technology gathered steam in the early 1980s. At times, Congress and/or the President have encouraged DOE to make technology transfer a priority and even made special funds available for this purpose for a short time in the mid-1990s. At other times, Congress and/or the President have viewed such activities as low priority or even undesirable and have discouraged active technology transfer activities. To some extent, this inconsistent support is reflective of the divergent points of view between the two major political parties about the proper role of the Federal government in helping industry. However, the support and opposition do not always align with the known political affiliation of individual Members of Congress, the President, or his cabinet officers. As a result, laboratory researchers and leaders may find themselves making commitments to technology transfer under one set of national leaders for which, later, they receive criticism. Needless to say, these mixed messages discourage both the laboratories and potential industrial partners from engaging wholeheartedly in technology transition activities involving the labs.

The preceding discussion should make clear that the DOE laboratories have highly diverse missions, capabilities, and organizational circumstances. They are hard to penetrate both legally and practically, and making arrangements for assistance, partnership or technology transfer is administratively complex. Finding ways to bring the technical capabilities of the laboratories to bear on industrial needs, while simultaneously avoiding a confrontation with political distaste for government assistance to individual companies and yet also responding positively to political demands to make the labs relevant to national needs, is a huge challenge for DOE leadership and laboratory managers.

The remainder of this report discusses recent developments in improving access to laboratory capabilities in order to help grow the American economy, modernize its energy infrastructure, and respond to the challenges of climate change and protection of the natural environment for a more sustainable future. In particular, the report will now examine the origins of DOE's new Office of Technology Transitions (OTT) and the role it plays in DOE's overall technology transfer efforts.

DOE'S NEW OFFICE OF TECHNOLOGY TRANSITIONS

WHY DID DOE CREATE THE NEW OFFICE?

Why did Secretary Moniz create the Office of Technology Transitions, why did he create it in February 2015 instead of at some other time, and what does he want it do and accomplish?

Two sets of factors led to the creation of OTT: (1) general interest by both the Obama Administration and a bipartisan group of Members of Congress in expanding DOE's contributions to commercialization, and (2) a specific initiative by a "policy entrepreneur" within DOE itself. Neither President Obama nor Congress directly created OTT; that was Secretary Moniz's decision. But their interest in increasing technology transitions from DOE apparently made Secretary Moniz receptive to the OTT proposal made by a member of his senior staff. It should also be noted that Secretary Moniz has a long history with and a deep knowledge of DOE. He had run a DOE-funded facility at MIT, and had served as Undersecretary of Energy in the Clinton Administration in the 1990s, and had also served in the White House Office of Science and Technology Policy. As a result, he has an unusually strong understanding of issues related to technology transfer at the laboratories, as well as the politics of the issue.

THE OBAMA ADMINISTRATION'S INTEREST IN DOE TECHNOLOGY TRANSITIONS

President Obama and his senior officials have long wanted to get greater commercial and economic value from federally-funded research and development, including R&D at the Department of Energy. For example, in October 2011 Mr. Obama issued a Presidential Memorandum encouraging additional federal efforts to promote technology transfer and commercialization.[5] Recent Administration policy statements have particularly emphasized the importance of federal "lab-to-market" programs. Examples of these statements include the R&D section of President's Obama's fiscal year (FY) 2017 budget request[6] and in the Administration's "Performance.gov" initiative.[7]

President Obama and DOE's leaders have particularly wanted the Department to help industry develop and commercialize clean energy technologies.[8] The Department has also emphasized the importance of helping general manufacturers and small businesses.

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[5] The White House, "Presidential Memorandum – Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Businesses," October 28, 2011, https://www.whitehouse.gov/the-press-office/2011/10/28/presidential-memorandum-accelerating-technology-transfer-and-commerciali.

[6] Office of Management and Budget, "Research and Development," in *Analytical Perspectives, Budget of the United States Government, Fiscal Year 2017*, page 303, available at: https://www.whitehouse.gov/omb/budget/Analytical_Perspectives.

[7] "Cross-Agency Priority Goal: Lab-to-Market," https://www.performance.gov/node/3395/view?view=public#overview.

[8] Clean energy has been one of President Obama's priorities since he took office, and it continues to be a high priority. For example, here is a recent White House statement: "The 2017 Budget provides $7.7 billion in clean energy R&D, demonstrating a strong commitment to the Mission Innovation pledge announced at the Paris climate change summit in 2015 to double Federal clean energy R&D investments over five years." This quote comes from: Office of Science and Technology Policy, "Fact Sheet: President's 2017 Budget Invests in American Innovation: R&D, Innovation, and STEM Education," February 9, 2016, https://www.whitehouse.gov/sites/default/files/microsites/ostp/ostp_fact_sheet_2017_budget_final.pdf.

As a result, the Obama Administration's DOE has expanded its technology transitions programs. In particular, the Department of Energy has launched three sets of initiatives to expand technology transitions and commercialization.

First, the President sought and obtained Congressional appropriations to expand energy technology R&D programs in DOE's Office of Energy Efficiency and Renewable Energy (EERE) and to begin operations at the Advanced Research Projects Agency-Energy (ARPA-E). Importantly, both EERE and ARPA-E have programs that work with industry to accelerate the development and use of new technologies. EERE has a Technology-to-Market Program, and so do individual offices within EERE, including the SunShot Initiative's Technology to Market effort and Building Technologies Office's Technology-to-Market Initiative.[9] ARPA-E has its own Tech-to-Market Program.[10]

Second, the Administration has run a controversial but largely successful loan guarantee program to help companies accelerate and produce new energy technologies.[11]

Third, the Administration has experimented with several initiatives to increase the commercial contributions of DOE laboratories.—including the weapons labs supervised by DOE's National Nuclear Security Administration (NNSA) and the science labs supervised by DOE's Office of Science (SC).

- ***Energy Innovation Hubs***. President Obama's first Secretary of Energy, Steven Chu, created four "Energy Innovation Hubs," described by DOE as "integrated research centers that combine basic and applied research with engineering to accelerate scientific discovery that addresses critical energy issues." These projects deliberately put DOE laboratories together with universities and companies to conduct not just basic research but actual engineering work. They thus use a model or theory of technology transitions that is more sophisticated than simply hoping that industry will use scientific

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[9] See: http://energy.gov/eere/technology-to-market/technology-market-program; http://energy.gov/eere/sunshot/technology-market; and http://energy.gov/eere/articles/building-technologies-office-challenges-national-labs-rethink-market-engagement. The term "lab to market" program is vague, but it usually includes a set of activities designed, as the EERE website says, "to strengthen public-private technology partnerships, accelerate the movement of new technologies into the marketplace, and train tomorrow's energy workforce." The EERE Technology-to-Market Program has several activities, including Lab-Corps, a Lab Impact Initiative, a Technologist-in-Residence Pilot Program (company engineers working in EERE), and an Energy Transition Initiative.

[10] See: http://arpa-e.energy.gov/?q=arpa-e-site-page/tech-market-t2m.

[11] See: http://energy.gov/lpo/loan-programs-office.

papers or patents developed by DOE labs. The hubs are a form of cooperative research *and* focused on actual engineering.[12]

- ***Agreements for Commercializing Technology***. On December 8, 2011, DOE announced a pilot program that provides a new way for laboratories to work with companies and academia. This new type of legal agreement, called Agreements for Commercializing Technology (ACTs), provides a more flexible framework for negotiating intellectual property rights, allows new payment and indemnification arrangements, and allows multiple parties to work together.[13] ACTs enable the laboratory contractor to absorb some of the risks of industry collaboration (e.g., the risk of industry non-payment and lawsuits) and let DOE waive the requirements for 60 day advance payment and indemnification, which have been a big barrier to industry collaboration. The laboratory contractor is allowed to charge industry a higher rate to compensate for this risks it takes on. This should enable faster partnerships with industry.

- ***Lab-Corps***. On October 29, 2014, DOE "launched a new $2.3 million pilot program to accelerate the transfer of innovative clean energy technologies from the DOE's National Laboratories into the commercial marketplace. Lab-Corps aims to better train and empower national lab researchers to successfully transition their discoveries into high-impact, real world technologies in the private sector."[14] This pilot program is based on the National Science Foundation's Innovation Corps (I-Corps) Program. It is an interesting attempt to enable interested DOE laboratory scientists to take the initiative in finding industrial partners to commercialize new discoveries.

- ***Small Business Vouchers Pilot***. DOE announced another new pilot program on July 8, 2015. This $20 million experiment allows several DOE laboratories to give money to more than 100 small businesses so that these companies can access lab expertise and tools.[15]

- ***DOE-sponsored Manufacturing Innovation Institutes***. To help general U.S. manufacturing, the Obama Administration has created a National Network for Manufacturing Innovation (NNMI), which consists of seven public-private Manufacturing Innovation Institutes (with two more now being created). DOE is the federal partner for two of these institutes: Power America, which is developing advanced manufacturing processes for semiconductors, and the Institute of Advanced Composites Manufacturing

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[12] See: http://energy.gov/science-innovation/innovation/hubs.

[13] See: http://energy.gov/articles/energy-department-announces-new-initiative-remove-barriers-industry-work-national-labs and http://energy.gov/articles/eight-national-labs-offer-streamlined-partnership-agreements-help-industry-bring-new.

[14] See: http://energy.gov/articles/energy-department-announces-new-lab-program-accelerate-commercialization-clean-energy.

[15] See: http://energy.gov/articles/new-national-labs-pilot-opens-doors-small-businesses.

Innovation. DOE will also support one of the two new institutes: the Innovation Institute on Smart Manufacturing.[16]

- ***Initiatives by individual DOE laboratories***. Some DOE laboratories, with support from DOE headquarters, have used some of their funding to work more closely with industry. For example, Lawrence Livermore National Laboratory and Sandia National Laboratories-California are creating a Livermore Valley Open Campus that will house new collaborations.[17]

These initiatives have several characteristics in common: a desire to make the NNSA and Office of Science laboratories more useful to industry, a willingness to experiment with new approaches, and an emphasis on relatively inexpensive initiatives in an era of tight federal budgets and Republican opposition to large new programs.

CONGRESSIONAL INTEREST IN DOE TECHNOLOGY TRANSITIONS

As discussed earlier in this report, in the mid-1990s Republicans in Congress eliminated funding for President Clinton's DOE Technology Transfer Initiative. However, beginning in 2005 Republican views changed somewhat.

Since President George W. Bush was in the White House in 2005, funding for DOE laboratories to work with industry was no longer a partisan political fight between a Democratic president and a Republican Congress. Instead, Republican and Democratic members of Congress who had DOE laboratories in their districts and states focused on how those laboratories could aid local economic development and overall U.S. industry. Republicans in general did not want to create expensive new programs, but they did consider low-cost options.

Section 1001 of the Energy Policy Act of 2005 (U.S. Public Law 109-58) directed the Secretary of Energy to do three things: to appoint a "Technology Transfer Coordinator," to establish a "Technology Transfer Working Group" within the Department, and to establish an "Energy Technology Commercialization Fund." In establishing the Fund, the Secretary is to use

> 0.9 percent of the amount made available to the Department for applied energy research, development, demonstration, and commercial application for each fiscal year, to be used to provide matching funds with private partners to promote promising energy technologies for commercial purposes.

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[16] See: http://manufacturing.gov/institutes.html and http://www.energy.gov/articles/energy-department-announces-70-million-innovation-institute-smart-manufacturing.

[17] See: https://lvoc.org/vision.html

The Bush Administration did little to implement these Section 1001 directives, and initially the Obama DOE claimed it was not required to set up a new Fund because it already was spending at least 0.9 percent working with private partners.

But Congressional interest in laboratory technology transfer and commercialization continued. Major "think tanks" have also called for additional technology transfer and commercialization efforts, which may have contributed to Congress's continuing interest in the subject.[18]

Three examples illustrate Congress' recent interest.

First, Section 319 of the Consolidated Appropriations Act, 2014 (U.S. Public Law 113-76), signed by the President on January 17, 2014, directed the Secretary of Energy to establish a "Commission to Review the Effectiveness of the National Energy Laboratories." Section 319 directed the Commission to focus on the overall effectiveness of the national laboratories and did not specifically mention technology transfer. But the Commission explicitly addressed technology transfer issues in both its interim report (dated February 27, 2015) and its final report (dated October 23, 2015). Here is one of the findings (as presented in both the interim report and the final report):

> Technology transfer and partnering with industry is an important part of the mission of the National Laboratories. While there are hundreds of CRADAs [Cooperative Research and Development Agreements] and other forms of collaboration with the private sector throughout the laboratory complex, support for technology transfer is inconsistent across the laboratories and across the DOE program offices.[19][20]

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[18] For example, see three recent reports: Information Technology and Innovation Foundation, Center for American Progress, and Heritage Foundation, *Turning the Page: Reimaging the National Labs in the 21st Century Innovation Economy*, June 2013; Scott Andes, Mark Muro, and Matthew Stepp, "Going Local: Connecting the National Labs to their Regions for Innovation and Growth," The Brookings Institution, September 2014; and *Technology Transfer and Commercialization Landscape of the Federal Laboratories,*Science and Technology Policy Institute, June 2011, https://www.ida.org/idamedia/Corporate/Files/Publications/STPIPubs/ida-nsp-4728.ashx

[19] Commission to Review the Effectiveness of National Energy Laboratories, *Interim Report of the Commission to Review the Effectiveness of National Energy Laboratories*, February 27, 2015, http://energy.gov/sites/prod/files/2015/02/f20/DOE%20Labs%20Commission%20Interim%20Report_Final.pdf. See also the Commission's final report: Commission to Review the Effectiveness of the National Energy Laboratories, *Securing America's Future: Realizing the Potential of the Department of Energy's National Laboratories: Final Report of the Commission to Review the Effectiveness of the National Energy Laboratories*, two volumes, October 23, 2015, http://energy.gov/sites/prod/files/2015/10/f27/Final%20Report%20Volume%201.pdf and http://energy.gov/sites/prod/files/2015/10/f27/Final%20Report%20Volume%202.pdf.

[20] TPI notes that this statement by the Commission is somewhat surprising. While one might want each DOE laboratory to explore opportunities to transfer technology, different laboratories have very different missions, capabilities, and constraints – and therefore very different opportunities for technology transfer. Energy

Second, on March 13, 2014, Senator Tom Udall (Democrat of New Mexico) introduced S. 2129, the proposed Accelerating Technology Transfer to Advance Innovation for the Nation (ATTAIN) Act. The bill proposed three key things: a permanent DOE technology transfer office, a new DOE technology transfer corps of people based on NSF's I-Corps program, and a program to increase money available to small startup companies that want to work with DOE. In his statement introducing the bill, Senator Udall also cited a February 2014 report from DOE's Inspector General that criticized the Department for not finalizing a Technology Transfer Execution Plan, for deficiencies with the Commercialization Fund, and for not filling the post of Technology Transfer Coordinator.[21]

Third, in 2014 a bipartisan group of members from the House of Representatives Committee on Science, Space, and Technology began work on a bill focused on technology transfer at DOE. Secretary Moniz and his staff knew about the proposed bill, and in fact the members introduced the bill – H.R. 1158, the proposed Department of Energy Laboratory Modernization and Technology Transfer Act of 2015 – in February 2015, the same month when Secretary Moniz decided to create the OTT. A slightly modified version of the bill passed the House of Representatives on May 19, 2015. As passed by the House, the proposed bill would do the following: require DOE to submit an annual technology transfer report, provide Congressional authorization for the Agreements for Commercializing Technology pilot program, make it easier for laboratory directors to sign agreements, allow laboratory demonstration projects, and allow DOE-funded researchers to participate in NSF's I-Corps program.

The Senate has not passed the bill, and it may not become law. But it is likely that Secretary Moniz noticed the strong bipartisan support in the House of Representatives.

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technology laboratories, such as the National Renewable Energy Laboratory, of course will work closely with industry. But the weapons laboratories and those of the Office of Science have specialized technical capabilities and facilities, some of which may interest some companies and some of which will not interest them. And of course much of the work at weapons laboratories remains secret. So, one should not expect a "consistent" amount of support for technology transfer from each laboratory.

[21] Statement of Senator Tom Udall, *Congressional Record*, March 13, 2014, pp. S1656-1657. See also, Office of Audits and Inspections, Office of Inspector General, U.S. Department of Energy, "Technology Transfer and Commercialization Efforts at the Department of Energy's National Laboratories," OAS-M-14-02, February 2014, http://energy.gov/ig/downloads/audit-report-oas-m-14-02.

A POLICY ENTREPRENEUR WITHIN DOE

An interview that TPI conducted with a former DOE staff member tells an interesting story of how a senior DOE official proposed the Office of Technology Transitions and how Secretary Moniz accepted that proposal.

In April 2014, President Obama formally nominated Dr. Ellen Williams to be the next director of ARPA-E – a position that requires the approval of the U.S. Senate. In the U.S. political system, there is often a period of time between when a person is formally nominated and when the Senate "confirms" (approves) that person, and during that time before confirmation some nominees serve as senior advisors to the government. This was the case with Dr. Williams. Between April 2014 and December 2014, when she became ARPA-E director, she served as a senior advisor in the office of the Secretary of Energy. One of the issues she worked on was technology transfer.

President Obama's first Energy Secretary, Dr. Chu, had appointed a Technology Transfer Coordinator, Dr. Karina Edmonds. Dr. Edmonds served in that role from 2010 to 2013. But she did not have many staff members, and her office played a limited role.

According to the former staff person interviewed by TPI, Dr. Williams proposed that Secretary Moniz not only appoint a new coordinator but also create and fund an office with sufficient staff, budget, and authority to play a significant role in expanding DOE's technology transfer and commercialization activities. In this sense, Dr. Williams was a "policy entrepreneur" who proposed a new office. Secretary Moniz apparently saw that both the White House and Congress wanted DOE to play a more active role in technology transfer, and that Congress also wanted DOE to create the Technology Commercialization Fund required by the Energy Act of 2005. Secretary Moniz also probably knew that the February 2014 interim report of Commission of Review the Effectiveness of the National Energy Laboratories would tell Congress that "support for technology transfer is inconsistent across the laboratories and across the DOE program offices."

Dr. Williams' proposal was a good solution to the political problem Secretary Moniz faced, and, as we have seen, on February 11, 2014, he announced the creation of the new Office of Technology Transitions.

WHAT ARE OTT'S MISSIONS, ACTIVITIES, AND RESOURCES?

As earlier sections of this report have discussed, OTT is only one part of an overall set of technology transfer and commercialization initiatives within the Department of Energy. But it plays a special role in these overall efforts.

OTT'S MISSIONS AND ACTIVITIES

OTT has several specific mission responsibilities. Some of them are tied to the requirements of the Energy Act of 2005 and others connect to the initiatives launched by the Obama Administration.

To begin with, OTT will serve as the Technology Transfer Coordinator required under the Energy Act of 2005. The Office's website provides a good summary of five other major responsibilities.

> In 2015, the Secretary of Energy authorized the formation of the Office of Technology Transitions, which is responsible for developing and overseeing delivery of the DOE strategic vision and goals for technology commercialization and engagement with the business and industrial sectors across the U.S., such as manufacturing, energy and technology....[22]
>
> The Office of Technology Transitions (OTT) conducts three key activities that are imperative to mission success – data management and analysis, evidence-based impact evaluations, and stakeholder engagement. The office also oversees two major DOE initiatives, the Technology Commercialization Fund and the Clean Energy Investment Center.[23]

In short, besides setting overall strategy and serving as the Technology Transfer Coordinator, OTT has five major activities.

The most visible of these five activities is the creation and administration of the Technology Commercialization Fund. The Fund now has $20 million per year available to match private funds to develop and promote promising energy technologies for commercial purposes. This is a small amount of money and will be awarded only once a year, so the commercialization fund might not have a big impact. However, if DOE decides to combine some its regular R&D funding with commercialization fund projects then this new initiative might significantly expand DOE-industry research collaborations.

On February 5, 2016, OTT issued its first solicitation (request for proposals) for this program. DOE's 17 national laboratories may submit proposals, and the winning laboratories will use the funds in joint projects with companies and other private-sector actors. DOE's press release on this solicitation also says that the Department believes that the Commercial Fund work will

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[22] See: http://energy.gov/technologytransitions/mission.

[23] See: http://energy.gov/technologytransitions/services.

complement DOE's efforts within "Mission Innovation" – the multi-national initiative "to double clean energy R&D within five years and drive technologies to market."[24]

In addition to administering the Technology Commercialization Fund, OTT's role in evidence-based evaluations is particularly important today, since DOE and the Administration as a whole have undertaken several important policy experiments. These policy experiments include not only Technology Fund itself but also the Agreements for Commercializing Technology pilot program and potentially Lab-Corps and the Small Business Vouchers Pilot. Evaluation will be an important aspect of learning which programs work and which do not.

The stakeholder engagement activity includes working closely with DOE and laboratory employees to understand issues, best practices, and areas for improvement. OTT will work here with the Technology Transfer Working Group established under the Energy Act of 2005. OTT also works with private-sector stakeholders (interested groups), including universities, investors, and companies.

OTT'S RESOURCES

To carry out these missions and activities, OTT Director Jetta Wong currently has a staff of seven professionals. Of course, the Office also works closely with other DOE officials and with technology transfer officers at DOE's 17 national laboratories.

For fiscal year 2017, President Obama has requested $8.4 million for OTT.[25] If Congress provides these funds, then OTT will have enough money to carry out its responsibilities.

One interesting feature of OTT is its organizational location within DOE. It is based in the Office of the Under Secretary for Science and Energy, so it has particularly strong organizational connections to the energy technology offices and the Office of Science. However, Director Wong also reports directly to the Secretary of Energy, which means she is indeed the Secretary's Department-wide official for technology transfer and commercialization.

WHAT RESULTS MIGHT OTT PRODUCE?

President Obama, his Administration, and a bipartisan group in Congress all want DOE to expand its efforts to develop and commercialize economically valuable technologies –

[24] See: http://energy.gov/articles/doe-s-office-technology-transitions-issues-first-call-launch-new-energy-technologies.

[25] Department of Energy, *FY 2017 Congressional Budget Request: Budget in Brief*, page 24.

particularly energy technologies but also technologies in other areas where DOE, it laboratories, and its university programs have strengths, including manufacturing and advanced materials.

OTT and its staff -- combined with the other DOE technology transfer initiatives mentioned in this report -- appear to have the authority, resources, and high-level political support to help the laboratories and DOE university programs to work more closely with industry. And the emphasis on program evaluation suggests that DOE will be able to learn which initiatives work best.

Three features of today's Department of Energy will influence how much OTT and the overall Department are willing and able to help industry develop and commercialize new technologies.

First, the new initiatives that OTT administers remain relatively small. For example, we noted above that the Technology Commercialization Fund has only $20 million per year. Lab-Corps and small business vouchers are also small experiments. One overall problem for the Obama Administration is that while the Republican-controlled Congress says it wants more technology transfer efforts, it does not want to provide significant new funding. In fact, occasionally Congressional Republicans propose major cuts in R&D funding at DOE and other federal agencies.[26] And if funds for technology transfer come out of funds for energy R&D (which may already include industrial collaborations), it is not clear if technology transfer will be enhanced.

Second, as discussed throughout this report, DOE's laboratories have diverse missions and capabilities, and not all laboratories are willing and able to work closely with commercial companies. The primary mission of the weapons laboratories is national security, not helping commercial industry, and their focus on specialized technologies and their need for secrecy limits how much they can help private companies. The laboratories under the Office of Science mostly focus on basic research. Some of their research and several of their research facilities are useful to industry, but historically they have not worked closely with a wide range of commercial companies.

Third, however, many parts of DOE have in fact worked closely with industry in the past, and the new initiatives at DOE may significantly expand those DOE-industry collaborations. To begin with, NREL and other DOE energy laboratories and R&D programs do work closely with energy

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[26] Some House Republicans want the government to support only basic research and eliminate or greatly reduce federal support for non-defense applied and commercial R&D. For details, see: American Institute of Physics, "House Budget Resolution Proposes Restructured Federal Science Apparatus, Foreshadows Likely CR," March 29, 2016, https://www.aip.org/fyi/2016/house-budget-resolution-proposes-restructured-federal-science-apparatus-foreshadows-likely.

companies, and some of this work has been very beneficial.[27] In addition, initiatives such as the energy hubs eventually build productive collaborations between DOE-funded researchers and private companies, including entrepreneurial companies as well as large established firms. If this happens, OTT will probably play a valuable role in helping to build new DOE-industry collaborations and also evaluating which types of collaborations work best.

CONCLUSION

DOE has a diverse mission and a diverse set of offices and laboratories – and most of these laboratories and programs do not focus primarily on commercialization. The weapons laboratories, the cleanup program at older weapons development sites, and the Office of Science's research laboratories all have missions other than helping commercial industry. Helping industry – through patent licensing, cooperative research, and allowing industry use of special facilities – is at best a secondary mission for these weapons and science programs.

Nevertheless, there are long-term pressures on DOE and the laboratories to add value to society in ways that goes beyond their original missions, and contributing to industry and economic growth is an element of this. OTT and other technology transition initiatives at DOE can play a valuable role in expanding connections between these programs and U.S. industry. Currently, OTT and related Obama Administration technology transfer initiatives do not have large budgets, but they have the potential to improve laboratory-industry collaborations.

OTT is a new policy experiment. If the next president, DOE secretary, and Congress show little interest in technology transfer and commercialization, then OTT probably will not be able to accomplish much in future years. However, if future political leaders support OTT and the entire idea of technology transfer and commercialization, then the Office and DOE's overall technology transfer efforts may flourish.

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[27] For example, these DOE energy laboratories and their R&D programs played a major role in helping the U.S. oil and natural gas industry develop the sophisticated hydraulic fracturing ("fracking") technologies that have greatly increased U.S. domestic petroleum and gas production. For information on this achievement, see: Michael Shellenberger, Ted Nordhaus, and Loren King, *Lessons from the Shale Revolution: A Report on the Conference Proceedings,* Breakthrough Institute, August 10, 2015, http://thebreakthrough.org/index.php/issues/natural-gas/lessons-from-the-shale-revolution, and Alex Trembath, Michael Shellenberger, Ted Nordhouse, and Jesse Jenkins, *US Government Role in Shale Gas Fracking History: An Overview*, Breakthrough Institute, March 2, 2012, http://thebreakthrough.org/archive/shale_gas_fracking_history_and.