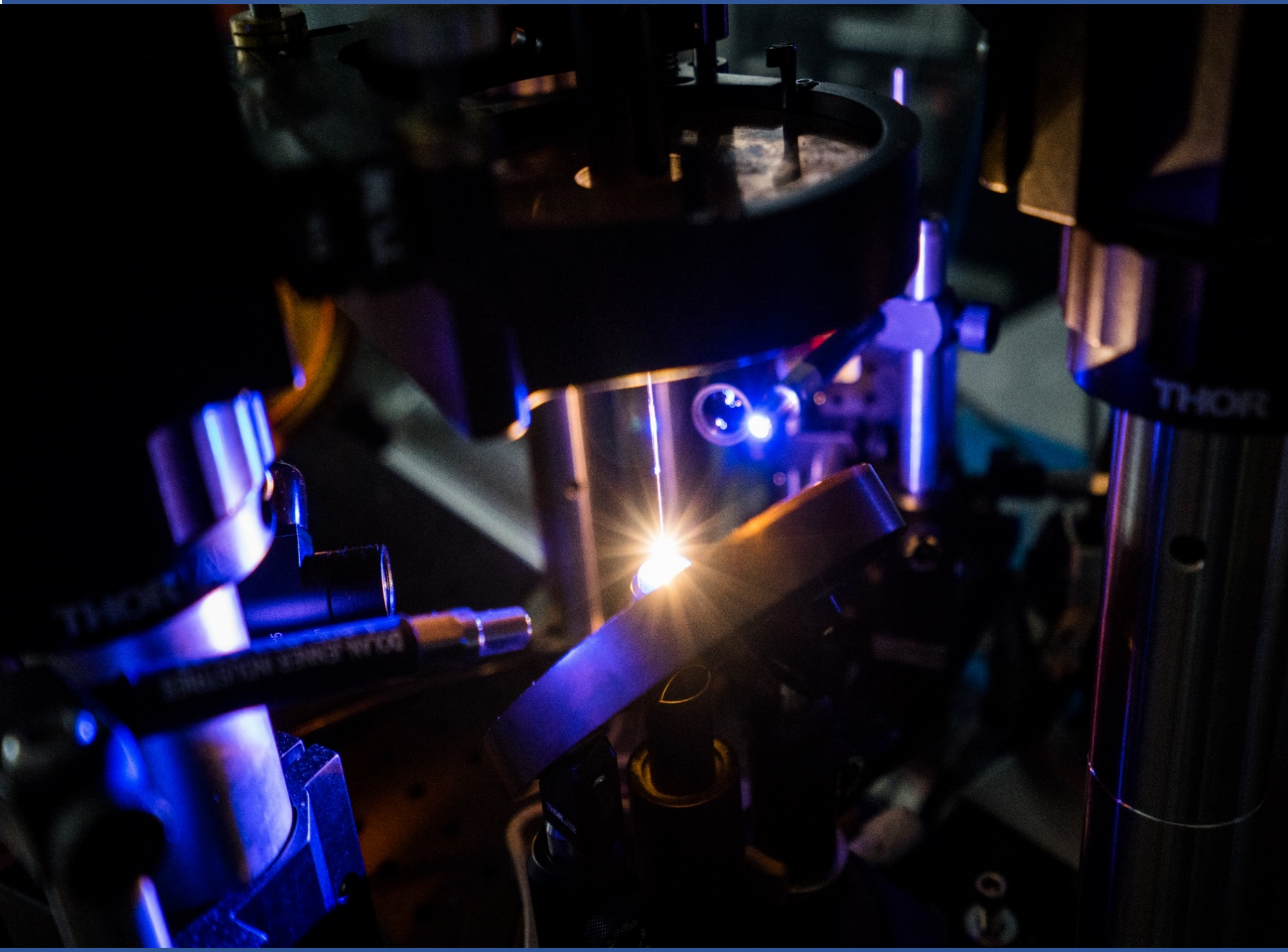
**A Report by a Panel of the**

NATIONAL ACADEMY OF PUBLIC ADMINISTRATION

**for the U.S. Department of Energy**

# An Innovation Foundation for DOE: Roles and Opportunities



NATIONAL ACADEMY OF PUBLIC ADMINISTRATION®

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# NATIONAL ACADEMY OF PUBLIC ADMINISTRATION

**January 2021**

# *An Innovation Foundation for DOE: Roles and Opportunities*

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# Foreword

The mission of the United States Department of Energy (DOE) is to ensure America's security and prosperity by addressing its energy, environmental, and nuclear challenges through transformative science and technology solutions. DOE accomplishes its mission by sponsoring basic research in the physical sciences; by promoting applied research and technological innovation; and by stewarding the nation's nuclear weapons complex.

The Conference Report on the Energy and Water Appropriations Act for Fiscal Year 2020 directs DOE to provide to the Committees on Appropriations of both Chambers of Congress a report on the value of creating a nonprofit foundation with requirements as outlined in the House and Senate Reports. DOE contracted with the National Academy of Public Administration (the Academy) to perform an independent assessment of the value of a nonprofit foundation to promote technology transfer through DOE programs and laboratories to the marketplace and for the broader public benefit. This assessment by an Academy Panel provides actionable recommendations that, when implemented together with related congressional initiatives, will enhance DOE's technology transfer activities.

As a congressionally chartered, non-partisan, and non-profit organization with over 950 distinguished Fellows, the Academy has a unique ability to bring nationally recognized public administration experts together to help government agencies address challenges. I am deeply appreciative of the work of the six Academy Fellows who served on this Panel. I also commend the Academy Study Team that contributed valuable insights and expertise throughout the project. I greatly appreciate the constructive engagement of DOE employees and many other individuals who provided important observations and context to inform this report. Given both the importance and complexity of DOE and its National Laboratories, I trust that this report will be useful to Congress and DOE leaders as they deliberate on the creation of a DOE foundation and plan for its future success.

Teresa W. Gerton
President and Chief Executive Officer
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# Table of Contents

# Acronyms and Abbreviations

| Acronym or Abbreviation | Definition |
|---|---|
| **ACT** | Agreement for Commercializing Technology |
| **AEC** | Atomic Energy Commission |
| **AEIC** | American Energy Innovation Council |
| **AL** | Ames Laboratory |
| **ALCF** | Argonne Leadership Computing Facility |
| **ARPA-E** | Advanced Research Projects Agency-Energy |
| **BPC** | Bipartisan Policy Center |
| **Brookings** | Brookings Institution |
| **CAP Goals** | Cross-agency Priority Goals |
| **CDCF** | Centers for Disease Control Foundation |
| **CEO** | Chief Executive Officer |
| **COI** | Conflict of interest |
| **COVID-19** | Coronavirus-19 |
| **CRADA** | Cooperative Research and Development Agreement |
| **CRENEL** | Commission to Review the Effectiveness of the National Energy Laboratories |
| **CRS** | Congressional Research Service |
| **DARPA** | Defense Advanced Research Projects Agency |
| **DoD** | Department of Defense |
| **DOE** | Department of Energy |
| **DR&D** | Directed Research and Development |
| **EERE** | Energy Efficiency and Renewable Energy |
| **EMSL** | Environmental Molecular Sciences Laboratory |
| **FAES** | Foundation for Advanced Education in the Sciences |
| **FDA** | Food and Drug Administration |
| **Fermilab** | Fermi National Accelerator Laboratory |
| **FFAR** | Foundation for Food and Agriculture Research |
| **FFRDC** | Federally Funded Research and Development Centers |
| **FLC** | Federal Laboratory Consortium |
| **FNIH** | Foundation for the National Institutes of Health |
| **FTE** | Full-time equivalent |
| **GAO** | Government Accountability Office |

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|---|---|
| **GOCO** | Government Owned, Contractor Operated lab |
| **GOGO** | Government Owned, Government Operated lab |
| **HHS** | Department of Health and Human Services |
| **HJF** | Henry M. Jackson Foundation for the Advancement of Military Medicine |
| **INL** | Idaho National Laboratory |
| **IP** | Intellectual Property |
| **IRS** | Internal Revenue Service |
| **ITIF** | Information Technology & Innovation Foundation |
| **LANL** | Los Alamos National Laboratory |
| **LDRD** | Laboratory Directed Research and Development |
| **LLNL** | Lawrence Livermore National Laboratory |
| **LOI** | Lines of inquiry |
| **LPS** | Lab Partnering Service |
| **M&O** | Management and Operating contract |
| **MDF** | Manufacturing Demonstration Facility |
| **NAS** | National Academy of Sciences |
| **NASA** | National Aeronautics and Space Administration |
| **NASEM** | National Academy of Sciences, Engineering, and Medicine |
| **NAVREF** | National Association of Veterans' Research and Education Foundations |
| **NBER** | National Bureau of Economic Research |
| **NCEM** | National Center for Electron Microscopy |
| **NERSC** | National Energy Research Scientific Computing Center |
| **NETL** | National Energy Technology Laboratory |
| **NFF** | National Forest Foundation |
| **NFWF** | National Fish and Wildlife Foundation |
| **NIH** | National Institute of Health |
| **NIST** | National Institute of Standards and Technology |
| **NLDC** | National Laboratory Directors' Council |
| **NMSBA** | New Mexico Small Business Assistance Program |
| **NNSA** | National Nuclear Security Administration |
| **NPF** | National Park Foundation |
| **NREL** | National Renewable Energy Research Laboratory |
| **NSF** | National Science Foundation |
| **NSLS** | National Synchrotron Light Source |
| **NSLS-II** | National Synchrotron Light Source II |
| **NSTC** | The National Science and Technology Council |

| | |
|---|---|
| **NSTX** | National Spherical Torus Experiment |
| **NTRC** | National Transportation Research Center |
| **OLCF** | Oak Ridge Leadership Computing Facility |
| **ORNL** | Oak Ridge National Laboratory |
| **ORTA** | Office of Research and Technology Applications |
| **OTT** | Office of Technology Transitions |
| **PEMP** | Performance Evaluation and Measurement Plan |
| **PGF** | Production Genomics Facility |
| **PMA** | President's Management Agenda |
| **PNNL** | Pacific Northwest National Laboratory |
| **PPPL** | Princeton Plasma Physics Laboratory |
| **PRI** | Program-Related Investments |
| **R&D** | Research and Development |
| **RD&D** | Research, Development, and Deployment |
| **Reagan-Udall** | Reagan-Udall Foundation for the Food and Drug Administration |
| **RFI** | Request for Information |
| **RHIC** | Relativistic Heavy Ion Collider |
| **ROI** | Return on Investment |
| **SBIR** | Small Business Innovation Research Program |
| **SBV** | Small Business Vouchers |
| **SEAB** | Secretary of Energy Advisory Board |
| **SNAL** | Stanford National Accelerator Laboratory |
| **SNL** | Sandia National Laboratories |
| **SNS** | Spallation Neutron Source |
| **SPP** | Strategic Partnership Projects |
| **SRNL** | Savannah River National Laboratory |
| **SSRL** | Stanford Synchrotron Radiation Laboratory |
| **STPI** | Science and Technology Policy Institute |
| **STTR** | Small Business Technology Transfer Program |
| **TCF** | Technology Commercialization Fund |
| **the Academy** | National Academy of Public Administration |
| **The labs** | DOE National Laboratories |
| **TIR** | Technologists in Residence |
| **TJMAF** | Thomas Jefferson National Accelerator Facility |
| **TRGR** | Technology Readiness Gross Receipts Initiative |
| **TRL** | Technology Readiness level |

| | |
|---|---|
| **TTWG** | Technology Transfer Working Group |
| **USDA** | United States Department of Agriculture |
| **VA NPCs** | Department of Veterans Affairs Nonprofit Corporations |
| **WNUF** | Wireless National User Facility |

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# Executive Summary

Over the past several decades, Congress created several agency-related nonprofit research foundations, such as the Foundation for the National Institutes of Health and the Centers for Disease Control (CDC) Foundation, to provide a flexible, efficient method to establish and enhance public-private research and development (R&D) partnerships. More recently, the Conference Report on the Energy and Water Appropriations Act for Fiscal Year 2020 directs the Department of Energy (DOE or the Department) to provide to the Committees on Appropriations of both chambers of Congress a report on the value of creating a nonprofit foundation with requirements as outlined in the House and Senate Reports.[1]

Consequently, DOE contracted with the National Academy of Public Administration (the Academy) to perform an independent assessment of the value of a nonprofit foundation to promote technology transfer through DOE programs and National Laboratories (or the labs) to the marketplace and for the broader public benefit.

The report of an Academy Panel of Fellows recommends the creation of a DOE foundation that would be complementary and supplementary to DOE, National Laboratories, and the growing set of lab-associated foundations. In its creation, the report urges the adoption of a "networked approach" that would involve a national level foundation working closely with current and future lab-associated foundations.

Working together, this network can reinforce and advance DOE's missions. The network can provide a flexible and efficient mechanism for establishing public-private R&D partnerships; enable the solicitation, acceptance, and use of private donations to supplement the work performed with federal R&D funds; facilitate the commercialization of federally funded R&D; further enable federal agencies to attract and retain scientific talent; facilitate information sharing across existing initiatives, and enhance public education and awareness regarding the role and value of federal R&D.

Pursuant to the Congressional request and the Academy's Statement of Work, the assessment consists of three primary components:

- An independent assessment of the potential value of a nonprofit foundation to promote technology transfer through DOE programs and the labs to the marketplace and for the broader public benefit;
- An examination of current federal agency-related nonprofit research foundations, focusing on their structure, governance, missions, and the roles that foundations serve in supporting the mission of their respective agency (see Figure 2.1, page 25); and
- An analysis of how a DOE foundation might complement the existing tech transfer activities of the current lab-associated foundations.

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[1] See https://www.congress.gov/bill/116th-congress/house-bill/1865/text

This report provides the findings and actionable recommendations that, when implemented together with related congressional initiatives, will enhance DOE's technology transfer activities. For the purposes of this report, the term "agency-related foundation" is a generic term relating to organizations such as the Foundation for the National Institutes of Health, the CDC Foundation, etc. The term "lab-associated foundation" relates to the three existing (and potential future) local foundations that were (or might be) set up by the DOE National Laboratories, which are affiliated with specific labs. Finally, the term "DOE foundation" relates to the proposed department-wide-related foundation for DOE.

**Findings and Recommendations:**

***A DOE foundation can play a complementary and supplementary role to the DOE, National Laboratories, and the lab-associated foundations.***[2]

In researching the function and capabilities of a foundation for DOE, the Panel reviewed the role of existing foundations, including those associated with other federal agencies. Further, the Panel examined the value that a foundation can provide for a diverse set of stakeholders, both internal and external to DOE. In the process, the Panel explored how this proposed organization can improve the technology transfer and networking activities of DOE and the National Laboratories and reinforce the work of lab-associated foundations. Based on this review, the Panel affirms the potential of a foundation to advance DOE missions, including but not limited to the commercialization of emerging energy technologies and innovation-based regional development.

**Finding A:** A DOE foundation could provide a complementary and supplementary role to DOE, National Laboratories, and the lab-associated foundations in areas where their missions are aligned.

**Recommendation A:** The Panel recommends the creation of a DOE foundation that would be complementary and supplementary to DOE, National Laboratories, and the lab-associated foundations. Further, the Panel recommends the adoption of a "networked approach" that would involve a national level foundation working closely with current and future lab-associated foundations.

***Successful agency-related foundations share similar characteristics and can reinforce their respective agency missions.***[3]

If structured and provisioned correctly, a DOE foundation could provide a flexible and efficient mechanism to advance the work performed with federal R&D funds.

**Finding B:** Successful agency-related foundations share similar characteristics:

- They are provisioned with sufficient funding to stand up the foundation and continued funding to support administrative expenses.
- They have enabling legislation and governance that clearly articulates the broad mission, the scope of activities, and structure of the foundation, including the design of its board of directors; appropriate governance and oversight mechanisms; and comprehensive conflict

[2] See the supporting discussion Chapters 4 and 5
[3] See the supporting discussion in Chapter 2.

of interest policies and procedures covering the relations among their board of directors, the agency and with potential and existing donors.

**Recommendation B:** The Panel recommends that Congress and DOE leaders consider the design features of successful agency-related foundations as an integral component when drafting enabling legislation and in the implementation of a new agency foundation.

- This design should include properly structuring, staffing, governing, and funding the organization.
- The foundation should be provided the flexibility and authority to respond to unexpected and unanticipated opportunities.
- The enabling legislation should include a clear mission statement with a focus both on commercializing new technologies, as well as integration within regional and national innovation ecosystems. This role should not be overly prescribed to avoid unnecessary limitations of the foundation's activities.

***A DOE foundation can provide value for private and philanthropic organizations.***[4]

Interviews with potential funders and research into science philanthropy identified several potential areas of collaboration for funding that could include, but not be limited to, community development, public engagement, and STEM education; promoting small businesses/scale-up of new technologies; and developing innovative technologies.

**Finding C:** There is significant interest among private sector and philanthropic funders to selectively collaborate with a DOE foundation.

- Philanthropic entities look for opportunities to make early investments in their areas of programmatic interest, serving as a catalyst for future investments from both the private and donor communities.
- These actors see a role for the DOE foundation as a connector. Areas of mutual interest include clean energy technology, emergent threats such as COVID and anthrax, the promotion of STEM education among underrepresented communities, and the commercialization of spinoff technologies.

**Recommendation C**: The Panel recommends that the proposed foundation leaders actively engage and collaborate with the private sector and philanthropic organizations to assess common areas of interest and future collaboration opportunities, including but not limited to the following:

- Technologies developed in DOE labs and programs represent a diversified portfolio of value to potential donors and private sector entities.
- A foundation can serve as a pathway for DOE technology transfer to be made visible/accessible to external institutions.

[4] See the supporting discussion in Chapter 2.

- In this regard, the foundation should build upon and work with the Office of Technology Transitions (OTT) and serve as an enabling interface and intermediary.

***Technology transfer is now widely recognized as comprising multiple innovation pathways beyond the traditional, statutorily prescribed metrics.***[5]

The definition of "technology transfer" has evolved and broadened over the years. Technology transfer is now widely recognized as comprising multiple innovation pathways beyond the traditional, statutorily prescribed metrics. The new paradigm prescribes a broad and inclusive definition of technology transfer that extends beyond the traditional metrics to include the full range of knowledge transfer mechanisms. This includes engagement with local communities, investments in startup companies to commercialize innovative technologies, promoting STEM education among underrepresented communities, and workforce development. Operating in this new paradigm, DOE and its labs can play a valuable role not only through research and promoting technology transfer but in reviving the nation's innovation and manufacturing ecosystems.

**Finding D:** The Panel recognizes the value of a broad concept of technology transfer as a multi-level approach, inclusive of the varied ways that knowledge, facilities, and technologies are diffused, disseminated, and deployed for public benefit through direct, indirect, and network pathway mechanisms.

**Recommendation D:** The Panel recommends that a broad contemporary definition of technology transfer should be incorporated in the design of a foundation.

- The foundation should be tasked to implement modern technology transfer activities to potentially include, but not be limited to, engagement with local communities, investments in startup companies to commercialize innovative technologies, promoting STEM education among underrepresented communities, and workforce training and development.

***A DOE foundation should encompass all of DOE's non-classified mission space.***[6]

Discussions with DOE staff and stakeholders suggest that an optimal role of the proposed DOE foundation is one that would encompass all of DOE's mission space. A foundation can promote DOE as a model for other federal agencies through, for example, initiatives that increase the level of engagement with small firms, leverage the activities of extramural programs, advance STEM education in regional ecosystems, and promote workforce equity and diversity.

**Finding E:** A widely acceptable role of a DOE foundation is one that would encompass all of DOE's non-classified mission space, thereby recognizing the potential contributions across all of DOE's constituent programs and organizational elements could make to achieve the proposed legislative purpose of a foundation.

**Recommendation E:** In the design of a foundation, the full range of DOE's varied responsibilities, technologies, and research should be embraced in the foundation's mission, consistent with the classification requirements of DOE's national security missions. [7]

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[5] See the supporting discussion in Chapter 3.
[6] See the supporting discussion in Chapter 3.
[7] The Panel recognizes the classified activities of the labs require appropriate safeguards.

***Discussions with the stakeholder community and Congress suggest that DOE's technology transfer activities can be advanced through continued legislative and agency refinements.[8]***

Current technology transfer policy and practice at DOE have continually evolved as a result of four decades of legislation governing all federal agencies, as modified by specific DOE legislation, and as traditionally tracked, arising from R&D as performed by DOE's national labs, sites, and plants.[9] Over the past two decades, Congress has demonstrated a consistent interest in enhancing DOE's capabilities to translate the results of its R&D into practical applications, with an increased focus on "clean energy applications."

**Finding F:** A successful DOE Foundation depends upon a robust DOE-led technology transfer program, and the pathway for an enhanced DOE technology transfer program resides in the optimization of its current organizational structure and mechanisms by continued Congressional action and agency initiatives:

- through continued internal process improvements,
- through broader legal authorities, dedicated funding, delegated and decentralized implementation,
- through tangible and visible incentives for the National Laboratories through performance management metrics and similar accountability mechanisms, and
- through visible agency leadership at the highest levels.

**Recommendation F:** In recognition of the contemporary definition of technology transfer, and building upon DOE's existing technology transfer structure, as may be enhanced by the actions identified in the above Finding, a *DOE foundation should identify and amplify those existing DOE and National Laboratory program activities where the foundation's mission and capabilities could add value to increase effective technology transfer*.

***Lab-associated foundations can, as appropriate, adopt the broader concept of technology transfer to play a valuable role in supporting the local community.[10]***

Lab-associated foundations can support technology transfer across the diversity of lab activities and processes in multiple ways. They can enhance the regional connectivity and external engagement of the labs, contribute to regional economic development, address the needs of the frontline community, and advance the mission of the labs.

**Finding G:** Lab-associated foundations can help connect the unique capabilities and resources of each lab to other regional and national stakeholders. They can help both the government-owned and government-operated National Energy Technology Laboratory, and the government-owned and contractor-operated labs grow regional innovation networks while also improving the flow of technology transfer within the labs.

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[8] See the supporting discussion in Chapter 3.
[9] See Figure 3.1 on page 51 for a breakout of these activities.
[10] See the supporting discussion in Chapters 4 and 5

**Recommendation G:** DOE should encourage, with Congressional action as may be required, the establishment of lab-associated foundations that are suited to the diverse characteristics, technical capabilities of individual labs, and the needs and resources found in the regional economy of each particular lab.

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# Chapter 1: Introduction to the Study

## 1.1 Introduction to the Department of Energy

The United States Department of Energy (DOE or the Department) engages in a broad scope of activities, primarily focused on the areas of defense, energy, and the environment. DOE's mission is to "ensure America's security and prosperity by addressing its energy, environmental, and nuclear challenges through transformative science and technology solutions."[11] DOE achieves its mission by promoting scientific and technological innovation to meet those challenges; sponsoring basic research in the physical sciences; and ensuring the environmental cleanup of the nation's nuclear weapons complex. Finally, In the absence of underground testing, DOE certifies the safety and security of the nuclear stockpile through its use of sophisticated science, engineering, and computational tools.[12]

DOE traces its roots back to the Manhattan Project and the U.S. Atomic Energy Commission (AEC). The AEC was created by the Atomic Energy Act of 1946 to take over the Manhattan Project's sprawling scientific and industrial complex.[13] During the Cold War, AEC designed and produced nuclear weapons and developed nuclear reactors for naval use. Following the Atomic Energy Act of 1954, AEC was given the authority to extend government use of the atom to develop the commercial nuclear power industry and the ability to regulate this industry. AEC later became the Energy Research and Development Administration (ERDA) in 1974. DOE was created on August 4, 1977, when U.S. President Jimmy Carter signed the U.S. Department of Energy Organization Act of 1977 to provide a national framework for energy production, distribution, marketing, and pricing. "DOE undertook responsibility for long-term, high-risk research and development of energy technology, federal power marketing, energy conservation, the nuclear weapons program, energy regulatory programs, and a central energy data collection and analysis program."[14]

Reflecting its broad and diverse activities, DOE includes numerous program offices, including the Office of Science, Office of Energy Efficiency and Renewable Energy, Office of Environmental Management, Office of Fossil Energy, and Office of Nuclear Energy, as well as the semi-autonomous National Nuclear Security Administration (NNSA). These offices steward the seventeen National Laboratories as well as four NNSA Production Facilities. The DOE National Laboratories (the labs) are a system of facilities and the labs overseen by DOE for the purpose of advancing science and technology to fulfill the Department's mission. Sixteen of the seventeen labs are federally funded research and development centers (FFRDC) operated as government-owned, contractor-operated (GOCO) labs. They are administered, managed, operated, and staffed by private-sector organizations under management and operating (M&O) contracts with DOE. The National Energy Technology Laboratory is an exception and is a government-owned and government-operated (GOGO) lab.

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[11] U.S. Department of Energy, About. https://www.energy.gov/about-us
[12] Ibid.
[13] U.S. Department of Energy, Brief History of the Department of Energy. https://www.energy.gov/lm/doe-history/brief-history-department-energy
[14] Ibid.

The FY 2021 budget request for DOE totals $35.4 billion in discretionary funds versus an enacted amount of $38.5 billion for FY 2020.[15] The FY 2021 budget request allocates the following amounts to different DOE programs:

- Energy: $ 3,603 million
- Science: $5,856 million
- National Security: $26,891 million
- Administration and Oversight: $215 million

DOE's Office of Technology Transitions (OTT) is a hub for technology transfer activities across the Department's research and development enterprise.[16] Its mission is to "expand the public impact of the Department of Energy's research and development portfolio to advance the economic, energy, and national security interests of the Nation."[17] OTT facilitates external access to the seventeen labs and sites with their scientific researchers and fosters internal and external partnerships to propel innovations from the lab to market.

Over several decades, Congress has created several agency-related nonprofit research foundations to provide a flexible, efficient method to establish and enhance public-private research and development partnerships. Examples of those foundations include the Foundation for Food and Agriculture Research, the Foundation for the National Institutes of Health, the National Foundation for the Centers for Disease Control and Prevention, the Reagan-Udall Foundation for the Food and Drug Administration, and the Henry M. Jackson Foundation for the Advancement of Military Medicine.

More recently, the Conference Report on the Energy and Water Appropriations Act, 2020 directs DOE to provide the Committees on Appropriations of both chambers of Congress a report on the value of creating a nonprofit foundation with requirements as outlined in the House and Senate Reports.[18] The House Report references a "report on the value of creating a nonprofit foundation that will better promote the transfer of technology to the marketplace," while the Senate Report requests a report "regarding the value of creating a nonprofit foundation to assist the Department to advance its mission of addressing the nation's energy challenges." [19,20] Both reports direct a review of how other agency foundations engage with the private sector to support "the research, development, demonstration, and commercial application of …" in the case of the House report, "innovative technologies," and in the Senate report, "innovative energy technologies."[21]

The Senate Report directs DOE to contract with the National Academy of Public Administration (the Academy) to convene an expert panel of Fellows to assess the value of creating a nonprofit foundation to help the Department advance its mission of addressing the nation's energy challenges. Further, the report shall include an assessment of comparable foundations at other

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[15] This amount includes Savings and Receipts -$722 and a reduction for Loan Programs and ARPA-E -$480. For a breakout, see https://www.energy.gov/cfo/listings/agency-financial-reports
[16] U.S Department of Energy Office of Technology Transitions, *The Office of Technology Transitions*. https://www.energy.gov/technologytransitions/office-technology-transitions
[17] U.S. Department of Energy Office of Technology Transitions, About us. https://www.energy.gov/technologytransitions/mission-0
[18] "Public Law No: 116-94", (Washington, DC. 2019) https://www.congress.gov/bill/116th-congress/house-bill/1865/text
[19] "Senate Report 116-102 Energy and Water Development Bill" (Washington, DC. 2020.) p.71
[20] "House Report 116-83 Energy and Water Development and Related Agencies Appropriations Bill" (Washington, DC. 2020.) p.117
[21] Ibid, p.69.; "House Report 116-83" 2020 p.117

federal agencies, with detail on their structure and governance, and how they engage with the private sector to enhance new and ongoing efforts supporting the research, development, demonstration, and commercial application of innovative energy technologies.[22]

As the House and Senate reports provide different guidance for the study and the conference report does not state which interpretation the Academy should follow, the Study Team interviewed current and former congressional staff as well as representatives from the Congressional Research Service (CRS), the Government Accountability Office (GAO), and DOE's senior leadership to better understand congressional interest related to the foundation study. Chapter 3 of this report discusses congressional intent in establishing a DOE foundation and recent legislative initiatives.

## 1.2 The Role of the Academy

In this report, the Panel provides DOE with an independent assessment of the value of a nonprofit foundation to promote technology transfer through DOE programs and National Laboratories to the marketplace and for the broader public benefit. The Study Team's primary government interface was OTT at headquarters. Pursuant to the statement of work, the assessment consists of three primary components:

- An independent assessment of a nonprofit foundation's value to promote technology transfer through DOE programs and the labs to the marketplace and for the broader public benefit;
- An examination of federal agency-related nonprofit research foundations, focusing on their structure, governance, missions, and the roles that foundations serve in supporting the mission of their respective agency*;* and
- An analysis of how a DOE foundation might complement the existing technology transfer activities of lab-associated foundations.

## 1.3 Study Scope and Lines of Inquiry

The Study Team defined the study scope along several lines of inquiry *(LOI)*. In addition, the Study Team identified key questions to guide its research. Those lines of inquiry and attendant research questions included the following:

**LOI One**: Examine other agency foundations that engage in research and development.

- What are the key structural characteristics and attributes of agency foundations?
- What are the best practices and characteristics that contribute to the success of an agency foundation?
- What are the key attributes related to good governance? What are the key challenges?
- What policies and procedures are necessary to ensure good governance?
- What roles can a foundation perform to support the mission of the agency?

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[22] Ibid

- How do comparable foundations engage with the private sector and industry to support the research and development and the commercial application of emerging technologies?

**LOI Two**: Assess the value of a nonprofit foundation to promote technology transfer through DOE programs and National Laboratories to the marketplace.

- Based on the experience of other agency foundations, how might a department-wide foundation contribute to DOE's technology transfer goals and objectives?
- Given the vast scope of DOE activities and research technology, what are the expectations among DOE internal stakeholders for an agency-wide foundation?
- What are the goals that DOE associates with such an entity (i.e., fundraising, governance, research flexibility, economic development)?
- What are DOE's current challenges in innovation and public-private-partnership activities? What elements can be enhanced? Are there internal structural or cultural impediments that may contribute to those challenges?
- What are the organizational and performance incentives related to technology transfer and their implications for innovative activities and initiatives of different scales and characteristics at DOE?
- What are appropriate qualitative and quantitative metrics to assess the potential value of a DOE foundation?

**LOI Three**: Determine whether existing laboratory-associated foundations may be complemented by a DOE foundation.

- What are the missions, structures, and functions of the National Laboratories?
- What are the missions, structures, and functions of the existing DOE foundations associated with the National Laboratories?
- What are the potential challenges and opportunities related to implementing an agency-wide foundation?

## 1.4 Methodological Approach

The study was conducted from May through December 2020 and employed a mixture of qualitative and quantitative research methods as outlined in the team's research design. The Study Team's research was conducted in several phases, as outlined below.

- ***Phase One: DOE Research: May-June 2020***

  The Study Team sought to acquire a preliminary knowledge of DOE activities, programs, and structures, including those operated by the head office program offices and National Laboratories. This included a review of DOE activities, programs, and strategic objectives related to the development and transfer of innovative technologies. Further, the team cataloged the activities and performance objectives of the National Laboratories; researched the activities, leading practices, and performance metrics of comparable agency foundations; and began an initial round of semi-structured interviews.

In addition, the Academy selected six Academy Fellows to serve as the expert panel for the study. Panel members were selected based on their expertise in relevant subject areas. Their biographies appear in Appendix G.

- ***Phase Two: Field Research: July-October 2020***

  In July, the Study Team commenced its fieldwork in accordance with the project's research design and the three lines of inquiry provided above. The Study Team's fieldwork spanned four months and comprised several different research techniques. The following is a brief description of field research activities:

  - **Review of official documents and related literature:**

    The Study Team completed an extensive review of documents including DOE annual reports, policy documents, Strategic Plans, and Congressional Budget Justifications; federal policy guidance and reports on technology transfer activities; reports from external stakeholders including CRS, GAO and the Office of Inspector General; House and Senate legislation related to the DOE foundation; related advocacy literature; and relevant academic studies. Appendix A provides a complete list of documents and related literature.

  - **Data collection**: To better understand the span of DOE's technology transfer activities, including those operated by the program offices and National Laboratories, the team collected and analyzed the performance metrics utilized by those entities and the attendant data for FY 2016-2018.[23] The team also reviewed the Technology Transfer, Commercialization, and Partnerships components of the FY 20 Annual Laboratory Plans of various National Laboratories. In addition to providing a discussion of those activities, the plans articulate each lab's vision and their immediate and future strategies. Finally, the team interviewed head office staff to confirm the team's understanding of the data collected.

  - **Semi-structured interviews**: The Study Team conducted 115 interviews, including senior leadership from DOE program offices, select agency and non-agency nonprofit foundations, external stakeholders, and subject matter experts. For each interview, the team prepared an interview guide with tailored discussion questions and an overview of the Academy study. Interviewees were advised that their comments were not for attribution. Figure 1.1 provides a breakout of the interviews per category. Appendix B provides a full list of interviews and attendees.

[23] At the time of report writing, FY 2019 data on tech transfer was not available to the Study Team.

**Figure 1.1: Completed Interviews**

| DOE Program Offices; Internal Stakeholders | Federal Agency Foundations | Nonfederal Agency Foundations | Other Stakeholders and Subject Matter Experts |
|---|---|---|---|
| 60 Interviews | 22 Interviews | 10 Interviews | 23 Interviews |

(Figure 1.1: Completed Interviews, created by the National Academy of Public Administration)

- **Survey of the 17 National Laboratories**

  The Study Team administered a survey to the 17 labs. The survey provided a vehicle to engage with the labs on technology transfer initially and informed the subsequent discussion framework of the focus group sessions. Survey participants included technology transfer staff from each of the labs. Appendix C provides more detail on the study methodology, and a copy of the survey can be found in Appendix D.

- **Focus Groups*:***

  Building on the data collected from the Lab questionnaires, the Academy conducted a series of virtual focus groups with the 17 National Laboratories. The labs were divided into six groups according to the DOE program office and the type of research conducted at the labs. Attendees were drawn from the tech transfer staff at each laboratory. The purpose of the focus groups was twofold:

  - to engage in a dialogue on tech transfer activities including the current state, future strategy, and potential obstacles; and
  - to solicit feedback on how a DOE foundation might add value in the context of the lab's tech transfer activities.

## 1.5 Key Study Assumptions

In evaluating the potential value of a DOE foundation, the Academy adopted several basic study premises or assumptions:

- ***The study assumes a broad and inclusive definition of technology transfer*:**

  Recognizing DOE's multiple missions and the Department's diverse range of technologies with varying technology maturity, the Study Team adopted a broad and inclusive view of technology transfer. This definition extends beyond invention disclosures, patent applications, and license agreements to include the full range of tech transfer mechanisms such as Strategic Partnership Projects (SPPs), Agreements for Commercializing Technology (ACTs), and Cooperative Research and Development Agreements (CRADAs); knowledge transfer mechanisms, including peer-reviewed publications, convening conferences and workshops, providing access to Lab facilities for external research, post-doc opportunities, etc.; engagement with local communities, promoting STEM education among underrepresented communities, and workforce development.

- ***The study is an independent and neutral assessment*:**

  Throughout its field research, including interviews and focus group sessions, the Study Team adopted a neutral approach--it did not advocate for the creation of a foundation or any specific model or structure.

- ***The study calls for a multi-dimensional approach:***

  The Study Team recognizes that a department-wide foundation is one of several congressional initiatives to promote the commercialization of innovative DOE technologies. For a foundation to be successful, DOE leaders and Congress will need to pursue additional legislative and policy initiatives. Incentivizing a traditional technology transfer program at DOE may benefit from several actions including, but not limited to: Congressional action and senior Agency leadership, including new authorities as outlined in recent legislative proposals, dedicated, and expanded funding, articulation of technology transfers as an agency priority, and further emphasis on technology transfer in the Performance Evaluation and Measurement Plans (PEMPs).[24]

  Further, in evaluating the potential value of a DOE foundation, the Academy did not attempt to identify or solve specific problems related to DOE technology transfer activities. The study asks what more can be done and how a foundation might complement and supplement current activities.

- ***The study assumes that the foundation's enabling legislation would provide the requisite funding, governance, and structural attributes*:**

  If an agency foundation were to be created, the enabling legislation must provide the requisite funding for administrative and operational costs, structure, and governance for the foundation to be successful. Chapter Four provides guidance on the necessary attributes.

## 1.6 Organization of the Report

This report consists of five chapters. A summary of the chapters appears below.

**Chapter 1** reviews the congressional request for the study and the Academy's role to provide an independent assessment of the value of a DOE foundation, while introducing DOE. Second, the chapter provides a description of the study, including scope, goals, methodology. The chapter concludes with an overview of the organization of the report.

**Chapter 2** provides a comparative analysis of existing federal agency research foundations. It provides the key attributes of a successful agency foundation ranging from the enabling legislation

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[24] Recent legislative proposals have proposed to authorize the pilot Small Business Voucher program, name the OTT Coordinator as the Chief Commercialization Officer reporting directly to the Secretary, and extended to NETL special hiring authority and the ability to fund a Directed Research and Development program, similar to LDRD. See Congressional interest, Proposed Legislation in Chapter Three for a complete discussion. Several recent studies, including those authored by CRENL, SEAB, and NAPA, point to a re-balancing of the relationship and redefinition of the roles of Program Office oversight and Lab Autonomy - specifically, greater flexibility to the Labs. Please see Chapter three above and the related Appendix for a summary of these reports.

to governance and congressional appropriations. Finally, the chapter concludes with a summary of lessons learned derived from the various interviews with federal agency foundations.

**Chapter 3** discusses federal interest in technology transfer, the legislative background, and the driving factors. Second, the chapter researched and provides a definition of technology transfer and discusses the various technology transfer initiatives at the Department level. The chapter concludes with an overview of various internal and external studies that evaluate the success of those initiatives.

**Chapter 4** reviews the technology transfer initiatives of the seventeen National Laboratories. The chapter begins with a historical review of the mission of the labs, research, and management. The chapter continues with a discussion on the technology transfer mission of the labs and the key challenges. The chapter concludes with a brief overview of the existing three lab-associated foundations.

**Chapter 5** discusses opportunities for expanding DOE innovation and technology transfer using both local and agency-wide foundations. Based on the team's research, it describes the essential characteristics of a successful foundation. Next, the chapter reviews the advantages of both a DOE foundation and a lab-associated foundation. Finally, the chapter presents the report's findings and recommendations.

# Chapter 2: The Foundation Role

The central question at the heart of this study is the potential value of a national nonprofit foundation to promote technology transfer through DOE programs and the labs to the marketplace and for the broader public benefit. Recognizing the breadth and complexity of the DOE structure, this study explores three related questions that underpin the study's analysis. First, how might the Department and the National Laboratories fully adopt and embrace the idea of a national foundation as a tool to better deliver their standard technology transfer mandate? Here, the issue is whether a foundation, as an organization external to but associated with the DOE complex, can affect the internal incentive structures and institutional culture found within DOE and at the National Laboratories.

A second and related question concerns the extent to which a foundation can supplement and complement the existing technology transfer toolkit utilized by DOE and its National Laboratories. Finally, the third question asks how a foundation can help foster the industrial and financial ecosystem that is needed for the scale-up of technologies developed by and in collaboration with the Department and its National Laboratories. While this chapter explores the key attributes of federal agency-related nonprofit research foundations and corporations, Chapters 4 and 5 discuss how DOE and the labs might utilize a national foundation to both complement and supplement its current technology transfer activities.`

The task of exploring the potential value of a national DOE foundation to promote technology transfer starts with understanding the organizational context, governance, and potential roles of an agency foundation. In this regard, this chapter reviews existing congressionally mandated, federal agency-related nonprofit research foundations and corporations that may serve as potential models for a newly created DOE foundation.

Further, to ascertain the potential value of a DOE foundation, this chapter examines the key attributes of successful agency foundations and their roles to support the mission of their related federal agencies. It identifies best practices and the characteristics that contribute to the success of an agency foundation—specifically focusing on the legal and structural aspects, policies and procedures that contribute to good governance, and the importance of enabling legislation and appropriations to ensure future success. Finally, the chapter reviews additional potential benefits of these foundations, including enabling the solicitation, acceptance, and use of private donations to supplement federal Research and Development (R&D) expenditures.

Congressional interest in establishing agency foundations is motivated in part by their successful record in leveraging federal Research and Development (R&D) expenditures to provide an efficient method to enhance public-private research and development partnerships. As highlighted in the 2019 Congressional Research Service publication, "Agency-Related Nonprofit Research Foundations and Corporations," many foundations have a successful record of raising external contributions far greater than their annual appropriations for administrative expenses.[25]

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[25] The CRS publication details the mission, structure, and activities of existing federal agency affiliated foundations as well as the potential benefits. For more information see "[Agency-Related Nonprofit Research Foundations and Corporations." Congressional Research Service, December 9, 2019.]

Further, the CRS study cited several stated goals and potential benefits of agency-related foundations. They include:

- To provide a flexible and efficient mechanism for establishing public-private R&D partnerships;
- To enable the solicitation, acceptance, and use of private donations to supplement the work performed with federal R&D funds;
- To increase technology transfer and the commercialization of federally funded R&D;
- To further enable federal agencies to attract and retain scientific talent; and
- To enhance public education and awareness regarding the role and value of federal R&D.[26]

## 2.1 Comparative Analysis of Existing Foundations

To better understand the best practices and attributes that contribute to a foundation's future success, the Academy selected and analyzed a sample of eleven federal agency foundations and corporations:

- Centers for Disease Control Foundation (CDCF),
- Foundation for Advanced Education in the Sciences (FAES),
- Foundation for Food and Agriculture Research (FFAR),
- Foundation for the National Institutes of Health (FNIH),
- Henry M. Jackson Foundation for the Advancement of Military Medicine (HJF),
- In-Q-Tel, a 501(c)3 that supports national security and the intelligence community
- National Forest Foundation (NFF),
- National Fish and Wildlife Foundation (NFWF),
- National Park Foundation (NPF),
- Reagan-Udall Foundation for the Food and Drug Administration, and
- National Association of Veterans' Research and Education Foundations (NAVREF).[27]

Of the eleven, six are focused on research and development, including FNIH, CDCF, Reagan-Udall, FFAR, HJF, and NAVREF. In addition, the Academy examined non-agency foundations to understand the broader non-profit sector best practices and to create the additional context for a

[26] Ibid, 1
[27] NAVREF is not a congressionally authorized foundation but serves in a capacity building role for the Department of Veterans Affairs nonprofit corporations (VA NPCs).

potential DOE foundation. The key attributes of the ten congressionally authorized foundations are provided in Figure 2.1 below.

**Figure 2.1: Overview of Congressionally Authorized Agency Foundations**

| Foundation | Year Established | Annual Appropriation | Total Revenue* | Endowment | Initial Appropriation |
|---|---|---|---|---|---|
| Centers for Disease Control and Prevention Foundation (CDCF) | 1992 | $1,250,000 | $80,222,442 | Yes | $500,000 |
| Foundation for Advanced Education in the Sciences (FAES) | 1959 | None | $32,505,369 | No | None |
| Foundation for Food and Agriculture Research (FFAR) | 2014 | Match of $200,000,000 every 5 years | $96,367,514 | No | $200,000,000 |
| Foundation for the National Institutes of Health (FNIH) | 1990 | $500,000 | $56,417,049 | Yes | $500,000 |
| Henry M Jackson Foundation for the Advancement of Military Medicine (HJF) | 1983 | None | $489,884,724 | Yes | $10,000,000 |
| IN-Q-TEL | 1999 | $92,635,358 | $116,697,968 | No | $28,700,000 |
| National Forest Foundation (NFF) | 1990 | $3,000,000 | $20,437,232 | Yes | $3,000,000 |
| National Fish and Wildlife Foundation (NFWF) | 1984 | $7,022,000 (National Fish and Wildlife Service) $3,000,000 (National Forest Service) | $304,393,817 | No | None |
| National Park Foundation (NPF) | 1967** | $5,000,000 | $70,913,760 | Yes | None |
| Reagan-Udall Foundation for the Food and Drug Administration (Reagan-Udall) | 2007 | $1,250,000 | $2,440,624 | No | $500,000 |

(Figure 2.1 created by the National Academy of Public Administration)[28]

## 2.2 Key Characteristics

As part of the study's comparative analysis, the Academy team reviewed key characteristics of the eleven selected agency foundations and corporations. The following is a description of those characteristics and how they vary by foundation. This comparison includes a description of the foundations' tax and legal status; an examination of the enabling legislation written to establish most agency foundations (which includes funding, purpose and scope of activities, and board design); a review of the key structural components including board, staffing, and finances; and a discussion on the governance mechanisms of oversight, conflict of interest policy, and independence.

[28] Information gathered from foundation websites, congressional language, and 990 forms. 990 forms are annual financial statements required by the IRS. More information on foundations can be found in Appendix F. *Total Revenue includes annual appropriation **Year authorized.

### *2.2.1 Tax and Legal Status:*

Over several decades, Congress has established agency foundations that take the form of quasi-governmental entities. They have been established to amplify and catalyze mission areas of importance to federal agencies. While agency foundations are independent nonprofit organizations, their enabling legislation, government funding, and close relationship with the parent agencies create their quasi-governmental nature. All eleven federal agency foundations sampled are designated as 501 (c)(3) tax-exempt organizations by the Internal Revenue Service (IRS).[29]

Section 501(c)(3) is the portion of the Internal Revenue Code that allows for federal tax exemption of nonprofit organizations. The U.S. Department of the Treasury, through the IRS, regulates and administers the code. There are other 501(c) organizations, ranging from 501 (c)(1) – 501 (c)(29). For this report, the term foundation is describing a 501 (c)(3) nonprofit organization. Key Characteristics of a 501(c)(3) include the following.[30]

- Donations are tax-deductible. 26 U.S.C. § 170 provides a deduction for federal income tax purposes for donors who make charitable contributions to most types of 501(c)(3) organizations. Exemptions exist for state income, property, and sales tax but vary depending on the state.
- Must exist exclusively for charitable purposes. These include religious, charitable, scientific, testing for public safety, literary, educational, fostering national or international amateur sports, and prevention of cruelty to animals and children.
- Cannot have a substantial part of its activities be attempting to influence legislation (commonly known as lobbying) but can engage in advocacy.
- Entities that can seek the 501(c)(3) determination from the IRS include corporations, trusts, community chests, *limited liability companies (*LLCs*),* and unincorporated associations. The majority of 501(c)(3) organizations are nonprofit corporations.
- Foundations can operate under more than one part of the tax code. Based on its revenue sources, the DOE foundation would organize as a public charity rather than a private foundation under section 509(a)1.[31]

While there are other IRS designations, the 501(c)3 tax-exempt charitable organization designation would afford the DOE foundation the ability to operate in a similar model as the other eleven outlined in the rest of the chapter.

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[29] Tax-exempt status for each of the foundations is noted in publicly available IRS 990 forms, see bibliography for more information.
[30] "What is a 501(c)(3)?", *Foundation Group*, accessed October 28,2020 https://www.501c3.org/what-is-a-501c3/
[31] "Public Charities", IRS, accessed November 10, 2020. https://www.irs.gov/charities-non-profits/charitable-organizations/public-charities

### *2.2.2 Enabling Legislation*

Enabling legislation varies across the different agency foundations examined. While some foundations were established without congressional approval, the majority were established through acts of Congress.[32] Enabling legislation sets the initial parameters for agency foundations regarding funding, purpose, scope of activities, and board design. Each of these areas is a key characteristic of effective function of a foundation and will be discussed in the subsequent paragraphs.

- **Enabling Legislation – *Funding*:**

  Enabling legislation has provided a range of funding options for establishing foundations. The most frequently used model provides an amount of initial funding for administrative and operational costs and then provides an annual appropriation in the form of a dollar range (e.g., between $500,000 - $1,500,000). A few foundations, however, were not appropriated initial funding.[33] In addition, one foundation, FFAR, receives matching funds from USDA. In this case, a funding sum of $200,000,000 was provided with the condition that the foundation may use the funds "only to the extent that the foundation secures an equal amount of matching funds from a non-federal source."[34]

  Discussions with agency foundations suggest that an insufficient amount of initial seed funding increased the vulnerability of the foundation in the early stages of development. With insufficient seed funding, foundations are forced to calibrate their services in proportion to the levels of donations they raise, delaying their ability to achieve basic operational competence. For example, while the FNIH was initially written into statute in 1990, it was nearly six years until they were operational. Their subsequent success and mobilization were greatly attributed to the $200,000,000 grant from the Bill and Melinda Gates Foundation.[35]

  A sufficient initial appropriation is necessary to not only provide a sound financial base but also to provide credibility to the foundation. An initial appropriation followed by an annual appropriation for administrative expenses allows foundations to build their infrastructure and reduce their initial dependency on federal appropriations. It can also be attractive to philanthropy as potential donors are attracted to lower administrative costs so their support can more directly go towards programming. Similarly, a DOE foundation would benefit from an initial appropriation and subsequent annual appropriations for administrative expenses. Together, they would provide an early sound financial base, increased credibility, and a more attractive pitch to potential donors.

- **Enabling Legislation – *Purpose, and Scope of Activities:***

  The purpose and scope of foundation activities are established in enabling legislation. In most cases, legislation states that the foundation should support the agency's mission while

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[32] Some foundations like the VA NPCs were not enabled through legislation, instead they were developed independently and now have interactions with federal agencies and Congress.
[33] See figure 4.1
[34] "Agricultural Act of 2014" (Washington, DC. 2014.) Sec. 7602, 289.
[35] "Grand Challenges in Global Health" Gatesfoundation.org, accessed October 28, 2020 https://www.gatesfoundation.org/Media-Center/Press-Releases/2003/01/Grand-Challenges-in-Global-Health

maintaining its independence and quasi-governmental status. In addition, the stated purpose often includes a reference to another focused outcome. For example, while the FNIH is directed to serve in accordance with the NIH's mission, it also serves to "advance collaboration with biomedical researchers from universities, industry, and nonprofit organizations."[36] While enabling legislation establishes the purpose and scope of activities, board members and founding leadership create the mission statement in bylaws.

Some foundations have legislation that ties their purpose to the agency exclusively with no other focused outcome.[37] That can be advantageous as it provides clarity to stakeholders, but the narrow purpose can also limit the foundation's flexibility to work on non-agency activities. Further, foundation leadership noted challenges with potential donors when the purpose explicitly states it serves the parent agency's operations as it signals questions about independence. Likewise, foundation leaders spoke to the difficulties that a lack of clear purpose created for management.

Some foundation purposes and scope of activities have expanded over time to include more responsibilities, such as the U.S. Department of Veterans Affairs-affiliated research and education nonprofit corporations (VA "NPCs"). When first created in 1988, VA NPCs were established to "provide a flexible funding mechanism" for VA medical centers, but in 1999 this authority was expanded to include the ability to accept donations for education and training.[38]

Broader enabling legislation combined with a clear, concise, and actionable statement of purpose defined by Congress in the enabling legislation is seen as optimal, providing foundations the flexibility to grow with changing environments. A DOE foundation would benefit from legislation that outlines a clear and actionable purpose and scope of activities that is broad enough to provide flexibility as environmental factors change but detailed enough to provide guidance and clarity to internal DOE stakeholders.

- **Enabling Legislation – *Board Design:***

  Enabling legislation establishes the structure of foundations, including its board, staffing, and financing. Each is a required element for effective operation. The following section details these three areas, providing definitions of terminology, comparing federal agencies, and concluding with best practices and lessons learned.

### *2.2.3 Board*

The board of an agency foundation is accountable for the success of the organization and its strategic decision making. Ranging from 9 to 28 members, boards in federal agency foundations vary in size and in representation. Of the sample of 11 foundations examined, the median number

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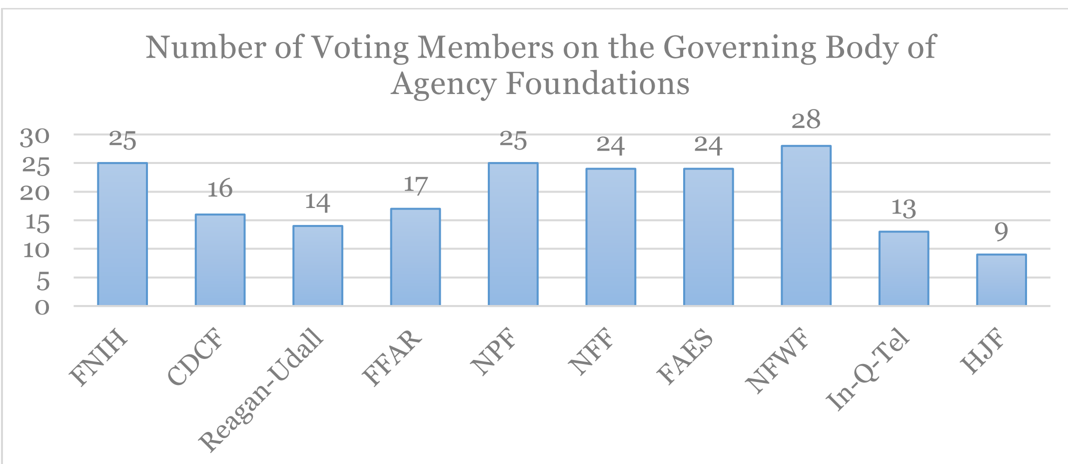
[36] "Title 42 The Public Health and Welfare" (Washington, DC. 1990.) 290b, 419
[37] Reagan-Udall Foundation. "Title 21 Food and Drugs" (Washington, DC. 2007.) 379dd, 380
[38] "Annual Report 2020." National Association of Veterans' Research and Education Foundations, 2020. https://www.navref.org/resources/Documents/Misc%20New%20site%20docs/NAVREF%20Annual%20Report%20-%202020-%20For%20Distribution.pdf . "Public Law 106-117" (Washington, DC. 1999.) 113, Stat. 1562
Additionally, the National Fish and Wildlife Foundation's (NFWF) mission states they are "dedicated to sustaining, restoring and enhancing the nation's fish, wildlife, plants and habitats for current and future generations." NFWF's enabling legislation was focused on mission and not on the agency responsible for it. The U.S. Fish and Wildlife Service, while a substantial partner, is not stated in their enabling legislation. This allows NFWF to maximize conservation investments by working closely with several federal and state partners. See "What We Do" National Fish and Wildlife Foundation, accessed October 28, 2020 https://www.nfwf.org/

of board members is 17. The number of voting members on the governing body (board or council of directors) is shown in figure 2.2. The general governance literature recommends board size be a function of representation goals, functionality, and efficiency.[39] Board member terms vary across the foundations examined, including four, five, or six years of commitment.[40] Interviews with board members highlighted the potential benefit of having term limits to provide rotating expertise and new connections to individuals and organizations.

Legislation can determine the process by which board members are appointed. Appointment varies and can be determined by the current board or require the signature of an ex officio[41] member from the agency. For instance, the National Forest Foundation (NFF) board appointment process requires the approval of the U.S. Forest Service Chief. Such approval can come with challenges described later in the chapter. Importantly, the majority of board members must be "independent" (not compensated by the organization or a related organization) to comply with IRS guidelines.[42] Legislation can also set mandates for categorical representation on the board. For instance, the FNIH is required to have four representatives from the "general biomedical field", two representatives from the "general biobehavioral field", and five representatives from the "general public."[43]

**Figure 2.2: Number of Voting Members on the Governing Body of Agency Foundations**




(Figure 2.2 created by the National Academy of Public Administration using publicly available data in IRS 990 forms.)[44]

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[39] "What Makes High Performing Boards", The Board Doctor, accessed November 11, 2020 https://www.theboarddoctor.info/uploads/7/8/3/9/78398336/14._what_makes_high_performing_boards_exec_summ.asae.pdf

[40] Term lengths in years are as follows: FNIH three to five, CDCF five, Reagan-Udall four, FFAR five, NPF six, NFF six, NFWF six, HJF four. Information is publicly available in enabling legislation and bylaws.

[41] Ex-officio, "from the office", refers to board members who gain membership from their position in government or industry.

[42] "Principles for good governance and ethical practice", Independent Sector, Accessed November 10, 2020, https://independentsector.org/programs/principles-for-good-governance-and-ethical-practice/principle-12/

[43] "Title 42 The Public Health and Welfare" 290b, p. 420. Similarly, the Reagan-Udall foundation is required to have 4 representatives of the "general pharmaceutical, device, food, cosmetic, and biotechnology industries", 3 representatives from "academic research organizations", 2 representatives of "patient or consumer advocacy organizations", 1 representative of "health care providers", and 4 at-large members with "expertise or experience relevant to the purpose of the foundation. "Title 21 Food and Drugs" (Washington, DC. 2007.) 379dd, 381

[44] Information gathered from publicly available 990 forms, see bibliography for more information.

Foundation boards typically consist of a mix of ex-officio members, non-voting members, voting board members, among whom officers are selected, such as a chair, treasurer, and secretary. Although the enabling legislation may determine the initial bylaws, which include board membership, term length and limits, conflict of interest policy, board size, and the number of ex-officio members, generally nonprofit boards make these decisions for themselves.

The majority of agency foundations have some form of ex-officio members. The most common form of an ex-officio board member is a non-voting representative from the parent agency. In this role, the parent agency member is invited to attend regular board meetings to contribute the agency perspective but does not hold voting power over decision making. In several foundations, ex-officio members include members of Congress, such as the committee chairman for the Armed Services Committee, who sits on the board of for the Henry Jackson Foundation for the Advancement of Military Medicine.

Depending on the mission of the foundation, board members will be expected to undertake different functions. In foundations that heavily engage in fundraising such as FFAR, CDCF, FNIH, NPF, and NFWF, board members are expected to make contributions or leverage their networks for philanthropic endeavors.[45] In contrast, in foundations that engage more in convening to bring experts across sectors together, such as the Reagan-Udall Foundation, board members are expected to contribute their subject matter expertise, federal agency knowledge, and or industry knowledge to help guide the foundation.[46]

There is a tradeoff between less and more prescriptive legislation for the foundation board. A less prescriptive approach allows for greater flexibility and efficiency as the board is able to draft a greater range of procedures in the bylaws. More prescriptive legislation provides greater oversight as members of Congress or other agency representatives can play larger roles in the board as ex-officio members. The value of additional oversight is a tradeoff in return for less board flexibility and efficiency. Foundation boards that have a political approval process, by the agency Secretary or even the White House, struggle with the timeliness of board approvals and can often be left with vacancies which, in some cases, reduce a foundation's ability to fundraise effectively and carry out other critical activities. For example, the National Park Foundation experienced delays in filling vacancies due to political approval processes that ultimately limited fundraising ability.[47]

While agency and other federal stakeholders lend critical expertise to foundation boards, foundation leaders cited more success when they are given the oversight of appointing and electing their board. The general governance literature also supports as best practice this principle of board independence and direct responsibility for the fiduciary obligations of a public charity.[48] A DOE foundation would benefit from a diverse, effective board –representing academia, industry, agency, and public stakeholders– because it allows for greater fundraising ability,

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[45] Interviews with referenced foundations. NFWF has board members that provide a contribution.

[46] Interviews with Reagan-Udall. According to the foundation's website, "The Foundation serves as a crucial conduit between FDA and the public, providing a means for FDA to interact directly with stakeholders, including industry" See https://reaganudall.org/about-us .

[47] Interview with National Park Foundation.

[48] "What Makes High Performing Boards", The Board Doctor, Accessed November 11, 2020 https://www.theboarddoctor.info/uploads/7/8/3/9/78398336/14._what_makes_high_performing_boards_exec_summ.asae.pdf

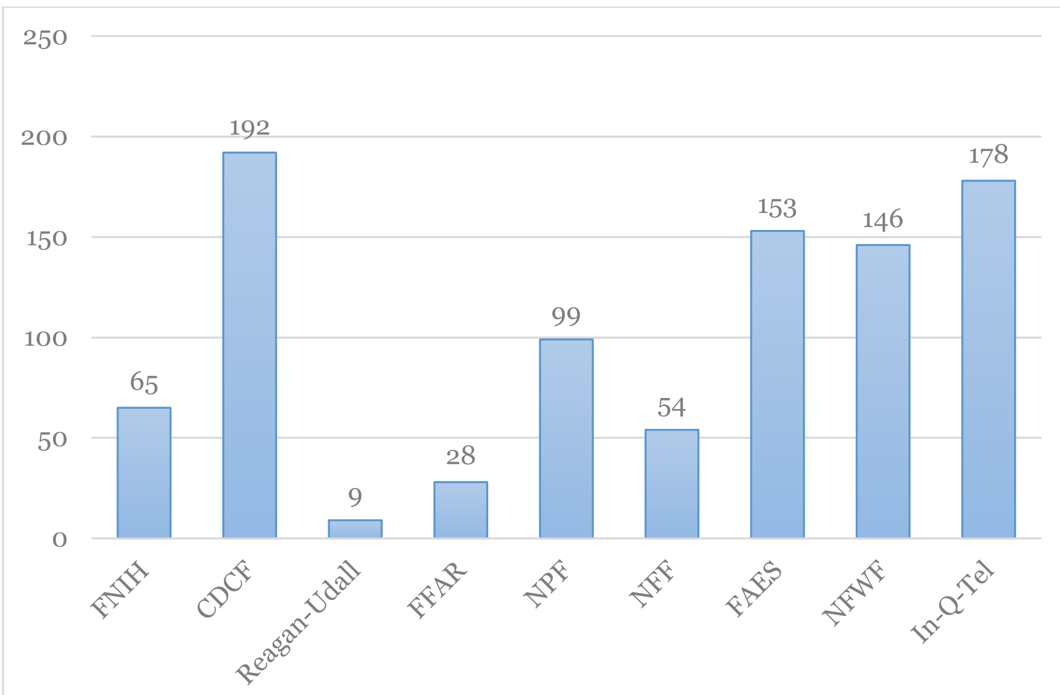
engagement with private sector trends, and more informed decision making and coordination with the foundation CEO.

### *2.2.4 Staffing*

Staffing is a core structural component of any organization. In terms of total full-time equivalents, existing foundations range in size from nine to 2,832.[49] After removing the two outliers of the VA NPCs and HJF, which have 2500 and 2823 respectively, most foundations have an average FTE count of 84. The FTE counts for the remaining nine foundations are shown below in figure 2.3. In addition to permanent staff, foundations have also exercised their ability to hire 'surge' staff to meet emerging needs.[50]

Foundation staffs consist of a combination of senior leaders, administrative employees, and technical advisers. Leaders guide the organization's strategic decision-making and are responsible for a variety of roles, including but not limited to fundraising, stakeholder engagement, operations, and public relations.

**Figure 2.3: FTE Count of Agency Foundations**




(Figure 2.3 created by National Academy of Public Administration using publicly available data in IRS 990 forms.)
*The HJF and VA NPCs were outliers and omitted from the graph, FTE counts are 2823 and 2500 respectively.

[49] Reagan-Udall foundation at 9, HJF at 2832. "Our Staff." Reagan-Udall Foundation. accessed October 27, 2020. https://reaganudall.org/about-us/our-staff.
"FY18-Form-990." Henry M Jackson Foundation for the Advancement of Military Medicine. ProPublica, 2018. https://projects.propublica.org/nonprofits/organizations/521317896

[50] For example, for the COVID-19 response CDCF expanded hiring to include upwards of 900 field staff to meet medical needs related to its COVID-19 response. For more information, see "Emergency Response Urgent Need COVID-19 Corps", CDC Foundation, accessed October 28, 2020. https://www.cdcfoundation.org/jobs

Foundations with fewer employees, such as the Reagan-Udall Foundation, rely on the chief executive officer (CEO) to undertake multiple roles within the organization.[51] Of the 11 foundations selected for this review, a majority have CEOs with prior parent agency experience. Staff with technical knowledge are also a significant resource for foundation management, especially in the existing foundations with medical or defense technology specializations, where the technical capacity of the staff enables effective collaboration with the parent agency and industry. Should a DOE foundation predominantly focus on engagement with the private sector and other industry and philanthropic partners, the foundation would benefit from staffing which assembles a strong team of technically and commercially experienced members while simultaneously hiring leaders in nonprofit management to effectively operate the foundation.

### *2.2.5 Finances*

As discussed, most agency foundations are funded through a combination of private donations and annual or permanent appropriations or other forms of budget authority. Some agency foundations also engage in fee-for-service initiatives, which add to the sustainability of their funding models. More than half of the foundations interviewed have set up an endowment that allows them to use investment income for a specific purpose. They all operate within the standards of their 501(c)3 IRS rules and regulations, including submitting an annual Form 990.[52]

Leaders of most agency foundations cited the ability to fundraise as a significant advantage of their 501(c)3 tax status, as the foundations are able to solicit funding that was not previously available to the agency. A foundation also provides funders a tax-exempt option to achieve the funders' mission goals and allows for the creation of donor-advised funds that can be tailored to the specific objectives of the prospective funder. Funds raised through traditional philanthropy may complement existing projects or provide the support to start new projects for many of the agency foundations. It bears mention that a foundation's Conflict of Interest Policies provide an important safeguard against potential conflicts of interest and undue influence that may arise from external contributions to a foundation. This theme is discussed below in section 2.2.8.

These more flexible funding mechanisms allow for amplification of the government's initial administrative investment. For instance, as figure 2.4 illustrates, funds raised by foundations that engage in traditional fundraising typically far exceed annual appropriations.[53] In the case of FNIH and CDCF, they were able to raise amounts well beyond their government-appropriated funding. Perhaps of greater significance, the COVID-19 pandemic has unveiled how foundations are able to quickly raise donor funds and flexibly deploy those funds for mission impact. They are able to hire surge staff and regrant funds for critical work in keeping the public healthy and safe.[54] The CDC Foundation and the FNIH provide two recent success stories that illustrate those capabilities. The FNIH raised funds for COVID-19 research by establishing a Pandemic Response Fund to attract donations from individuals, private sector foundations, and traditional philanthropic groups.[55] The CDC Foundation also established a fund and raised over $200 million

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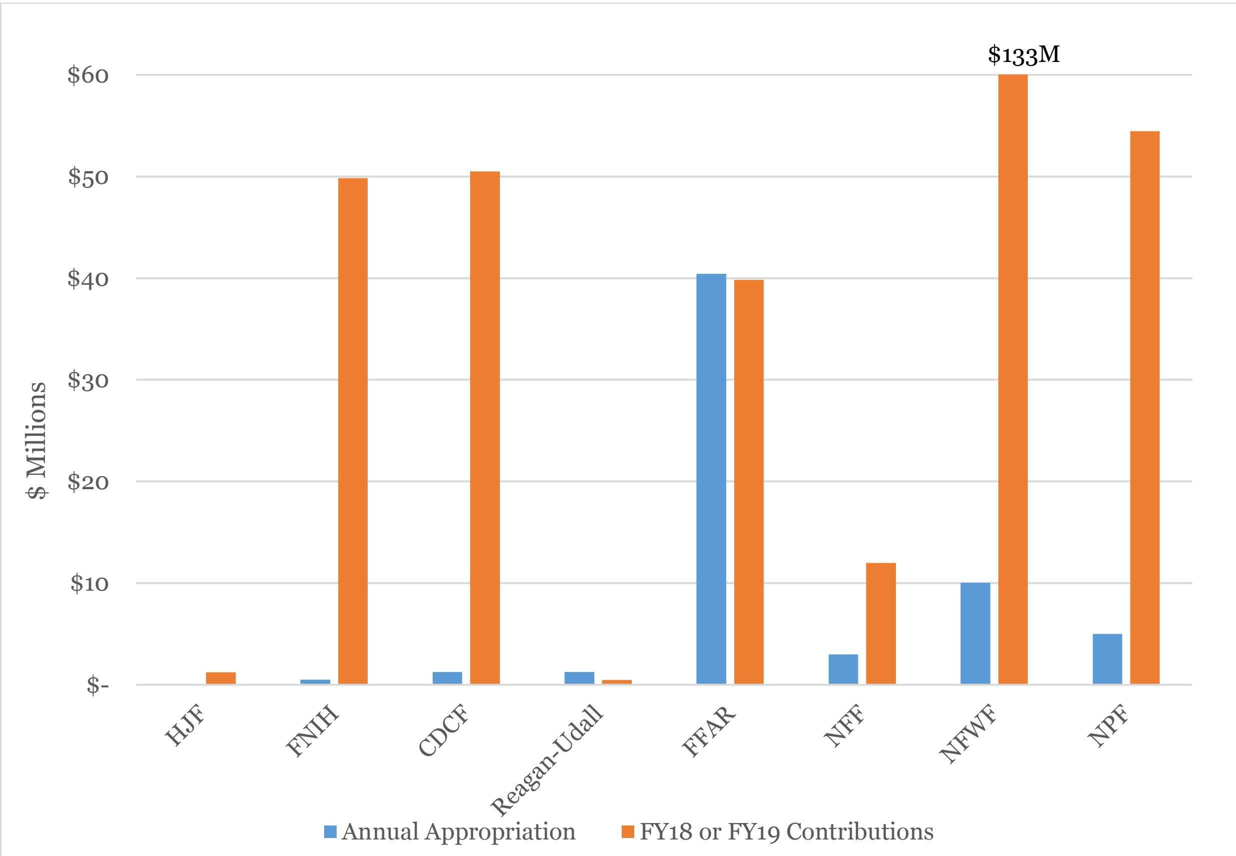
[51] Interviews with Reagan-Udall.
[52] More information can be found earlier in the chapter in figure 4.3.
[53] Note that FY19 contributions do not include additional revenue from fee for service, investments, and more Finish footnote
[54] "Emergency Response Urgent Need COVID-19 Corps", CDC Foundation, accessed October 28, 2020. https://www.cdcfoundation.org/jobs
[55] "Pandemic Response Fund Tracker", Foundation for the National Institutes of Health, October 26, 2020, https://fnih.org/pandemic-response-fund-tracker

from a diverse group of donors to support the foundation's COVID-19 response. The CDC Foundation deployed those funds in over 83 U.S. states, tribes, and territories, as well as other countries. Among the foundation's contributions, it distributed over 7.3 million pieces of personal protective equipment for frontline workers, provided laboratory and medical equipment, and hired more than 1,000 surge staff for state, local and territorial health departments.[56] The ability to pivot, deploy resources, and be agile when there are urgent areas of work is an advantage of foundations' structure and governance.

**Figure 2.4: Annual Appropriation vs. Contributions Received**




(Figure 2.4 created by National Academy of Public Administration using publicly available data in IRS 990 forms and annual reports.) *NFWF is an outlier with annual appropriations of $10,022,000 and contributions received of $133,250,201. It has been omitted from this graph to represent the other foundations.

Interviews with private foundations and other nonprofit entities identified additional tools that foundations can deploy to pursue program objectives. One such mechanism is program-related investments (PRI). As defined by the Internal Revenue Service, PRIs are those in which:

1. The primary purpose is to accomplish one or more of the foundation's exempt purposes;
2. Production of income or appreciation of property is not a significant purpose; and

[56] See "CDC Foundation Launches Crush Covid-19 Campaign To Meet Urgent Needs Caused By Pandemic", accessed on December 12, 2020, https://www.cdcfoundation.org/pr/2020/crush-covid-campaign

3. Influencing legislation or taking part in political campaigns on behalf of candidates is not a purpose.[57]

Another such mechanism is recoverable grants. These are loans issued to a non-profit group that are repaid under flexible, lenient terms. [58] They are used "as a financial tool in which nonprofits agree to repay private investors the principal amount and possibly an interest rate, based on their overall financial performance or that of a specific program, [and] are an emerging form of patient, affordable, and flexible capital in the United States." [59]

One of the foundations examined that is not Congressionally authorized advocates for funding. The National Association of Veterans' Research and Education Foundations (NAVREF) lobbies for "an increase in the annual appropriation of [the] VA medical and prosthetic research account" and works with the House and Senate Veterans Affairs Committees.[60]

As stated above, an important advantage of a foundation's 501(c)3 tax status is its ability to fundraise. While many agencies have the authority to accept philanthropic funding, they are not permitted to solicit private funds. Foundations are able to bring additional mechanisms and flexibility to solicit private funds, and research foundations specifically have utilized this ability to solicit private funding for a variety of missions as observed through the Academy's interviews and noted in the 2019 CRS report "Agency-Related Nonprofit Research Foundations and Corporations."[61]

While DOE GOCO labs and their associated foundations have greater flexibility in soliciting funds from outside entities, DOE as a federal agency does not. A foundation would allow for a centralized mechanism to engage funders, deploy resources across the Department, and mobilize quickly to respond to changes in the environment or the marketplace. Additionally, a DOE foundation could supplement the work of the lab-associated foundations to solicit donor funds for research.[62]

To illustrate the ability of agency foundations to leverage federal expenditures, the Academy compared their appropriation with the funding they provide by way of grants and awards. Figure 2.5 compares the annual appropriations of six agency foundations with the amount they regranted in that same year to other charitable organizations, universities, and back to the affiliated federal agency. This further demonstrates the ability of a foundation to expand the support for efforts funded by DOE-appropriations with fundraising efforts in order to substantially increase their impact.

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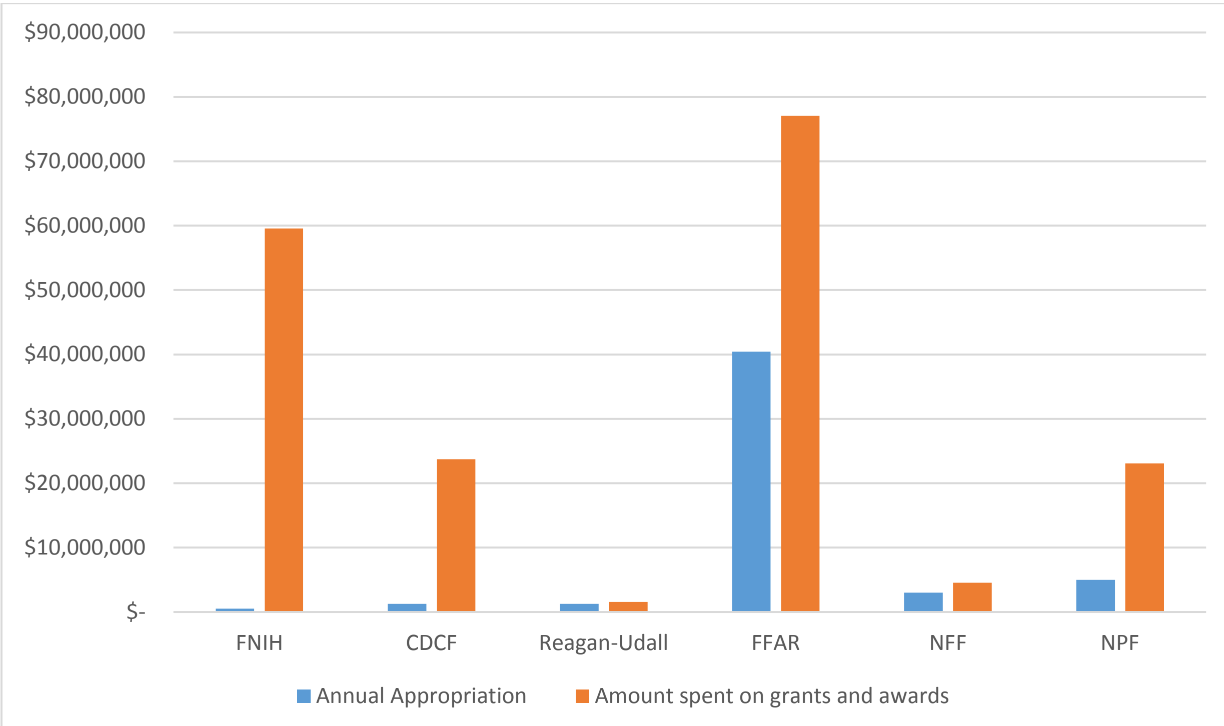
[57] "Program-Related Investments." Internal Revenue Service. accessed October 27, 2020. https://www.irs.gov/charities-non-profits/private-foundations/program-related-investments.
[58] Chamberlin, Alexandra. "France's 'Soft Loan' Model Paves Way for Recoverable Grants in US." Stanford Social Innovation Review, June 5, 2019. https://ssir.org/articles/entry/frances_soft_loan_model_paves_way_for_recoverable_grants_in_us.
[59] Ibid.
[60] "Advocacy", NAVREF, accessed October 28, 2020, https://navref.org/Advocacy
[61] "Agency-Related Nonprofit Research Foundations and Corporations." Congressional Research Service.
[62] For example, the Berkeley Lab Foundation received grant funds from the Gordon and Betty Moore Foundation to support the development of a unique microscopy concept pioneered by researchers at Lawrence Berkeley National Laboratory. The foundation then initiated a SPP to support the principal investigator of this project. See Chapter four for a more complete discussion.

**Figure 2.5: Appropriation vs. Funds Regranted/Awarded**




(Figure 2.5 created by National Academy of Public Administration using publicly available data in IRS 990 forms and annual reports.) *HJF and NFWF are outliers with total spent on research grants and contracts for HJF at $461,921,107 and NFWF $209,311,792. HJF does not receive an annual appropriation and NWFW received $10,022,000.

**Box 2.1: Foundation for the National Institutes of Health**

In 1990, the U.S. Congress officially established the Foundation for the National Institutes of Health. The foundation's purpose was spelled out in the enabling legislation – "to support the National Institutes of Health in its mission, and to advance collaboration with biomedical researchers from universities, industry, and nonprofit organizations."[63] The enabling legislation enumerated the general activities of the foundation. It noted the foundation's ability to "solicit and accept gifts, grants and other donations, establish accounts, and invest and expend funds" in support of those activities.

The legislation also outlined the Foundation's authority, the composition of the Board of Directors, the authority of the Executive Director, conflicts of interest, reporting, intellectual property rights, and more. With regards to intellectual property rights, much of the control is given to the Board of Directors – "The Board shall adopt written standards with respect to the ownership of any intellectual property rights derived from the collaborative efforts of the foundation prior to the commencement of such efforts."

As a 501(c)3 nonprofit organization, the FNIH raises and administers private funds and manages the relationships of individuals, corporations, and organizations to carry out research and educational programs in support of the mission of the NIH. This model's cited advantage is the exchange of ideas between NIH and private partners in a pre-or non-competitive environment that is not possible otherwise.[64] In 2011, FNIH went through a rebranding, creating new strategies to diversify and attract new donors and partnerships. More recently, they have been successful in raising their initial appropriation from $500,000 to an annual appropriation of $1,200,000. With every $1 they receive in appropriated monies, they can raise roughly $80, leveraging the government investment and providing even more value with the tax-payer dollar.[65]

### *2.2.6 Governance Mechanisms*

Governance mechanisms are a necessary feature of any foundation to ensure transparency and accountability. With congressional funding of agency foundations, the requirement for transparency and accountability is doubly important. In order to facilitate that these foundations act as good stewards of government funds, robust oversight, including COI policies and transparency, are required. The following section details the governance mechanisms used by our sample of federal agency foundations, their best practices, and lessons learned.

### *2.2.7 Independence and Oversight*

Agency foundations are required to maintain a minimum standard of independence from the parent agency and donors and do so through various means. As discussed above, foundations provide value to their respective federal agencies. However, this must be balanced with the requirement to maintain transparency and accountability in quasi-governmental organizations. Reporting requirements are established by legislation and boards to ensure transparency of the

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[63] "Title 42 The Public Health and Welfare" (Washington, DC. 1990.) 290b, 419-423
[64] "Frequently Asked Questions", Foundation for the National Institutes of Health, accessed December 16, 2020 https://fnih.org/about/faq
[65] Ibid.

operations of the foundation. To maintain their 501(c)(3) status, foundations submit an annual Form 990 and keep records of financial information on sources of support.[66] Additionally, most agency foundations are required by law to submit annual reports, document engagement with the agency, and hold public board meetings.

In cases where Congress directs a federal agency to provide funding to a foundation, Congress removes the agency's control over the amount of funding given to the foundation. This directive from Congress strengthens the independence of a foundation from the agency as the discretion over foundation funding is removed from agency control. For instance, NIH is required by Congress to provide the FNIH an annual appropriation of $500,000.[67] Likewise, Reagan-Udall receives a set range of funding between $500,000-$1,250,000, independent of the discretion of the FDA commissioner.[68]

Through legislation, authority is delegated to the board, not the agency, to determine the structural elements of the foundation. The board has oversight of the CEO, including selection, compensation, and performance. Legislation can also clarify independence in staffing. For instance, the FNIH enabling legislation differentiates between NIH and foundation employees. No NIH employee is allowed to sit on the board of FNIH in a non-ex officio capacity. Likewise, the legislation also states the FNIH does not have the authority to exercise administrative control over "any federal employee."[69] Legislation can also provide the foundation the authority and independence to establish the mission beyond just the statement of purpose. This provides the opportunity for a foundation to expand beyond only supporting the agency. In addition to the mission, ethical standards for the acceptance, solicitation, and disposition of donations are drafted by the boards of these foundations.[70]

As described in the 2019 CRS report, questions have been raised concerning the integrity of research at R&D agency foundations.[71] Among the R&D foundations interviewed, independence was created through screening processes for donations that could impede, or be seen to impede, the scientific integrity of research.[72] Conflict of interest policies are also in place which prohibit donors from selecting or shaping research processes. For instance, FFAR employs a rigorous peer-review process in which research projects pass through approval from FFAR experts to external technical experts, and then finally to an advisory council. Projects are assessed on a technical level and against "challenge areas" set by the foundation in keeping with its mission.[73] Foundations

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[66] "Applying for 501(c)(3) Tax-Exempt Status", Internal Revenue Service, accessed October 28, 2020 https://www.irs.gov/pub/irs-pdf/p4220.pdf
[67] Ibid, p.423
[68] "Title 21 Food and Drugs" (Washington, DC. 2007.) 379dd, 383
[69] "Title 42 The Public Health and Welfare" 290b, 420-422
[70] Reagan-Udall, CDCF, FNIH, FFAR. "Agency-Related Nonprofit Research Foundations and Corporations." Congressional Research Service. 6-9
[71] For instance, the House Committee on Energy and Commerce launched an investigation into allegations of influence from the National Football League on the selection of a grant recipient by NIH. The investigations ultimately ended in a report that included findings and recommendations directed at the FNIH in its role in the management of R&D partnerships between the NIH and the private sector, recommendations to ensure integrity. See "Agency-Related Nonprofit Research Foundations and Corporations." Congressional Research Service. 16
[72] "Foundation for the National Institutes of Health Donor and Funding Partner Selection Criteria." accessed October 28, 2020. https://fnih.org/sites/default/files/final/pdf/Donor%20and%20Funding%20Partner%20Selection%20Criteria%209July2018.pdf.
[73] "How We Work", Foundation for Food and Agriculture Research, accessed Oct 28 2020, https://foundationfar.org/about-us/how-we-work/

interviewed emphasized the importance of clearly maintaining and communicating the independent research process and expectations around the selection and results of research.

There are several ways in which agency foundations have created a successful governance structure that allows for healthy working relationships. They include putting in place collaborative agreements and memorandums of understanding that detail the scope of work, funding mechanisms, and responsibilities of all stakeholders, including the foundation, the agency, and external entities.

Similar to DOE's method of currently deploying cooperative research and development agreements (CRADAs), the foundation could benefit from additional mechanisms for providing governance and oversight, including MOUs between the foundation and the agency and potential collaborative agreements between the foundation and the National Laboratories.

### *2.2.8 Conflict of Interest Policy*

An effective conflict of interest policy offers another mechanism to ensure the foundation acts in the interests of the federal government and maintains public confidence. A COI policy provides a set of procedures for board members and staff to follow so that potential conflicts can be disclosed in advance of decision making. Additionally, a robust COI policy clarifies the procedure for addressing conflicts that arise, prohibits board members from voting on any matter in which they have an interest, and defines the criteria for determining what qualifies as a COI.

All federal agency foundations have a COI policy. Most foundations require potential board members to submit COI forms before they can be elected to the position. Likewise, COI procedures require annual attestations from board members to identify any new or ongoing conflicts. A COI policy should also apply to the staff who administer the organization, and it should be used in the screening process of potential donors. For instance, foundations may find when vetting donations that certain potential donors are not aligned with their mission or might signal inappropriate influence over their research endeavors. The 2019 CRS report supports information heard from the Academy interviews, which revealed that COI policies should cover the screening of gifts from donors (CDCF) and the submission of annual COI disclosure information (HJF), and, in certain cases, may subject the directors of the organization to federal COI laws and regulations (VA NPCs).[74]

The foundations sampled described additional applications of COI policies. In one case, during the board member selection process, the confirmation vote for one board member was postponed until a pending financial transaction viewed as a potential COI expired (NFF).[75] In another example, some foundations followed COI policies in disseminating information generated during research, to avoid the opportunity for insider trading. To achieve equity, the release of information is public and precedes any release to donors (FNIH).[76] Likewise, an analogous process could be considered to assure the research security interests of the DOE are respected.

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[74] "Agency-Related Nonprofit Research Foundations and Corporations." Congressional Research Service. 20
[75] Interview with NFF.
[76] David Wholley, FNIH, "New Ideas for Strengthening Partnerships at DOE National labs", ITIF Event, June 2020, https://itif.org/events/2018/06/27/new-ideas-strengthening-partnerships-doe-national-labs

COI policies may limit contributions from corporate partners. For instance, the CDCF distanced itself from donations from Coca-Cola so that foundation research regarding obesity and nutrition, initially funded by Coca-Cola, would not appear biased by the company's agenda.[77] This also highlights how the credibility of an agency foundation can ebb and flow with the perception of the agency, especially if the foundation has the agency in its name. A DOE foundation would benefit from robust COI policies as they are important for safeguarding against potential conflicts that reduce reputational integrity, an important feature of public charities.

## 2.3 Roles of Foundations

Structure and governance characteristics are critical to ensuring the success of any foundation and are requisites before operationalizing and carrying out the mission the foundation was created to fulfill. The Study Team's interviews revealed several roles performed by foundations, including private and public sector engagement; attracting and retaining diverse talent; and promoting research, training, and education. A DOE foundation could perform many, if not all, of these roles.

- **Private Sector Engagement**

  Securing partnerships and additional funding is a core role of almost all the agency foundations sampled. They all attract donations from philanthropic and private sector organizations to supplement any federal funds they may receive to perform their work. As a 2019 CRS report notes, "the global landscape for innovation is rapidly evolving" and "the composition of R&D funding has changed".[78] Also noteworthy, companies are the largest source of R&D spending in the United States, accounting for about$441 billion in 2018 ".[79]

  Agency foundations also convene stakeholders from the private sector to gain the expertise they need to support the agency's broader mission. Some agency foundations can interact more flexibly and efficiently with the private sector due to the parent agency's limited existing authorities and have catalyzed many public-private R&D partnerships.[80]

  A DOE foundation could attract donations from philanthropic groups and the private sector to supplement work performed with federal R&D funds.[81] It could also convene stakeholders from the private sector with expertise in technology commercialization to support the goals of the foundation.

  Foundations can also play a role in the commercialization of new technologies related to an agency's mission by creating a for-profit subsidiary-investment fund. This approach allows the foundation to purchase a minority equity stake in a for-profit startup without jeopardizing its tax-exempt status. The fund's investment signals the foundation's confidence in a

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[78] "Agency-Related Nonprofit Research Foundations and Corporations." Congressional Research Service.
[79]National Center for Science and Engineering Statistics Accessed on December 21 at https://ncses.nsf.gov/pubs/nsf20316/
[80] Tim Webb, Christopher Guo, and Jennifer Lamping Lewis, et al., "Venture Capital and Strategic Investment for Developing Government Mission Capabilities" RAND Corporation, 2014, pp. 6-8. Stuart Mendel and Jeffrey Brudney, "Putting the NP in PPP: The Role of Nonprofit Organizations in Public-Private Partnerships", Public Performance & Management Review, 2012, 622 https://www.jstor.org/stable/pdf/23484758.pdf
[81] "Return on Investment Initiative, Final Green Paper." National Institute of Standards and Technology. United States Department of Commerce, 2019. https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1234.pdf. 65

particular technology and can attract traditional market-rate investors, including venture capital firms.[82]

Foundations can further incentivize external private investment by "de-risking" the investment for market investors by using subordinated capital or a first loss arrangement whereby the fund's investment absorbs the initial losses of the startup. The above examples have been described as "catalytic capital" in which the contributing foundations take the risks that traditional investors are not willing to take and serve as a catalyst for future private investment.[83]

Two nonprofit foundations that have successfully invested in startups to commercialize new technologies are Prime Coalition and Washington Maritime Blue (WMB). Prime Coalition created the PRIME Impact Fund as a for-profit subsidiary to enable philanthropic entities to participate in investments primarily focused on carbon-reducing technologies.[84] Recently created, WMB focuses on clean energy and carbon-reducing technologies for the maritime sector.[85] In-Q-Tel is another example of a nonprofit foundation that invests in new technologies. As part of its broader mission, the foundation invests in commercially focused technologies that may contribute to U.S. national security.[86]

From the perspective of a DOE foundation, the foundation could foster the commercialization of new technologies by creating a for-profit subsidiary that would invest in both startup and scaleup opportunities. This approach could be of potential interest to both philanthropic and private sector entities interested in advancing clean energy and other emerging technologies.[87] DOE foundation investments in local startup and scaleup opportunities could also stimulate local and regional economic development in communities where DOE and its labs operate.[88]

- **Public Engagement**

All the agency foundations have a role in raising public awareness of the value of federal endeavors and specifically their role in R&D. Furthermore, many of these foundations are

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[82] Typically, startups do not have access to traditional private capital as the underlying technology has not been sufficiently proven.

[83] For additional discussion on catalytic capital see "Catalytic Capital at Work", MacArthur Foundation, March 12, 2019 https://www.macfound.org/press/article/catalytic-capital-work/#:~:text=Catalytic%20capital%20is%20defined%20as,otherwise%20would%20not%20be%20possible.

[84] "Our Story", Prime Impact Fund, accessed December 15, 2020 https://www.primeimpactfund.com/

[85] "Maritime Blue Capital Assessment", Washington Maritime Blue, September 19, 2019 https://maritimeblue.org/blue-capital-landscape/

[86] For more information on In-Q-Tel 's operations and mission see "About IQT" IN-Q-TEL, accessed December 21, 2020 https://www.iqt.org/about-iqt/

[87] For more information on basic science philanthropy see Ruby Barcklay, "U.S. Research Institutions Received Over $2.3 Billion in Private for Basic Science in 2017", June 7, 2018, https://sciencephilanthropyalliance.org/u-s-research-institutions-received-over-2-3-billion-in-private-funding-for-basic-science-in-2017-alliance-news/, Matthew C. Nisbet, "Strategic Philanthropy in the post-Cap-and-Trade years: Reviewing U.S. climate and energy foundation funding", March 27, 2018 https://web.northeastern.edu/matthewnisbet/2018/05/21/summary-of-strategic-philanthropy-in-the-post-cap-and-trade-years-reviewing-u-s-foundation-climate-and-energy-funding-at-wires-climate-change/, Interviews with foundations representing private companies revealed a potential interest in a DOE foundation. For instance, Wells Fargo seeks to position DOE as a strategic thought leader and innovator in clean technology, and in doing so supports the company's sustainability objectives. For more information see section 4.4.2 "Facilitating Collaboration with Industry" and Josh Rasmussen, "Wells Fargo Invests $20M To Extend Highly Successful IN² Incubator Program Through 2024", NREL, December 1, 2020, https://www.nrel.gov/news/features/2020/wells-fargo-invests-20m-extend-in2-incubator-program-through-2024.html

[88] Stephen Ezell and Scott Andes, "Localizing the economic impact of research and development", The Brookings Institution, December 2016, https://www.brookings.edu/wp-content/uploads/2016/12/bass_20161207_localizingeconomicdevelopment_paper.pdf 24, "Proceedings of a Workshop In Brief", The National Academies of Sciences, Engineering, and Medicine, February 2018, https://www.nap.edu/read/25022/chapter/1

more visible in communities than agencies are as they have direct interactions with citizens through marketing campaigns, crowdfunding initiatives, events and more. For instance, FNIH launched a crowdfunding campaign for COVID-19 in which a large portion of the funds was donated by members of the public. Many of the foundations have local education and workforce development programs. A DOE foundation could promote STEM education, further engage in workforce development by partnering with local communities and could generally engage the public on a broader range of initiatives.

- **Attract and Retain Diverse Talent**

  Some agency foundations leverage their quasi-governmental position to offer benefit packages and talent sourcing that complement agency capacities. Interviews with foundation leaders confirmed that agency foundations are well-positioned to attract and recruit diverse talent as they are not a federal government entity and therefore not subject to federal hiring practices and can have more flexible hiring processes than federal agencies. For some, this is an attractive attribute because it can also mean more flexibility in a given role. Foundations that serve this role are in the medical research field, where competition for scientific talent is high.[89]

  While DOE GOCO Labs have additional flexibility related to hiring practices, a foundation can provide additional flexibility agency-wide. A foundation can represent interests related to the agency's mission and through engagement in local and regional networks can help source and increase diversity in the scientific research community.

- **Research, Training, and Education**

  Most agency foundations have a training and education component. The R&D-specific foundations have created programs to train the next generation of scientists. Others have built award programs and training grants to further research in their mission areas. There are regulatory requirements that can present challenges for outside organizations to develop and jointly fund programs with agencies, so many agency foundations like FFAR play a role in bridging that gap.

  HFJ offers research and support services to the Uniformed Services University of the Health Sciences and other military research centers, including proposal development and research program management. VA NPCs also offer approved education and training activities for patients, their families, and VA employees. FAES conducts educational programs and supporting activities for the NIH campuses. Interviews with DOE labs suggest that the DOE foundation could play a role in providing education about technology transfer or commercialization or could provide training to technology transfer leaders.[90]

## 2.4 Lessons Learned

The Study Team's review of selected agency foundations identified important lessons learned regarding governance and the effective management of agency foundations. Some of these may

[89] Foundations who serve this role are HJF and FAES.
[90] As described in Chapter One, the Study Team conducted focus groups and semi-structured interviews of the 17 DOE National Laboratories.

be addressed in the foundation's enabling legislation, while others will be part of the foundation's policies and operating procedures.

- **Leveraging federal investment**. Foundations are able to utilize flexible funding mechanisms afforded to them through their tax status to leverage federal expenditures and support broader agency goals.
- **Complementary and supplementary foundation roles**. Foundations can perform a variety of roles to complement and supplement agency missions. Foundations engage with the private sector, conduct training, research, and education, attract talent, and engage with the public— all in support of the agency's broader goals.
- **The importance of funding, both at inception and annually**. The enabling legislation provides the foundation sufficient funding to stand up operations and continued funding to support administrative expenses. Initial seed funding from external donors also provides credibility and contributes to the sustainability of the foundation.
- **The importance of providing basic prerequisites**. The enabling legislation clearly articulates the broad mission, scope of activities, and structure of the foundation, including the design of its board of directors.
- **Appropriate governance and oversight mechanisms**. Governance mechanisms are critical to success and include appropriate independence between the foundation, its aligned agency, and its potential donors. Mechanisms include memoranda of understanding or collaborative agreements, and vetting procedures for the selection of new projects and acceptance of external contributions.
- **A board of directors with diverse representation**. Successful foundations are afforded the flexibility, dependent upon their needs, to appoint certain board members. Representatives from academia, industry, and the agency provide for a balanced and effective board.
- **Robust COI policies**. To ensure independence and good governance, foundations require comprehensive COI policies and procedures that cover the relationships between them, their board of directors, their agency, and their donors.

# Chapter 3: Technology Transfer at the Department of Energy

To understand how a foundation might complement DOE's technology transfer activities, it is instructive to review the Department's current level of technology transfer activity and the factors which affect its operations. To this end, this chapter summarizes the federal legislative history and statutes; describes the evolving definition of technology transfer and DOE's strategies and goals for technology transfer (including the perspectives of DOE personnel); presents a high-level survey of publicly available data describing DOE's current level of technology transfer activity, including innovative programs; summarizes the findings and recommendations from a breadth of independent, external and internal, studies and reports; and concludes with a discussion of proposed Congressional legislation.

### 3.1 Federal Legislative Background

DOE's legislative structure for technology transfer activities is common to that of most federal agencies. However, DOE's legislation for technology transfer activities have unique characteristics attributed to its WWII origins and subsequent guidance by DOE authorities and Congressional direction. This section provides the contextual background on how technology transfer was defined and the development of its legislative framework.

The development, protection, and dissemination of intellectual property, the basis of "technology transfer," was enshrined in the U.S. Constitution. Article I, Section 8, gives Congress the power: *"To promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries."* This provision originally drew upon two centuries of European experience in the promotion of industrial activity.[91] As the United States grew to be an industrial power in the 19th century, there was an emergence of the intentional use of science to promote industrial productivity. This included the federal government establishing organizations such as the Smithsonian Institution in 1846 (its first Laboratory), the National Academy of Sciences in 1863, and the National Bureau of Standards in 1901.[92]

During World War II, federal support for scientific discovery through research universities and government organizations - including Massachusetts Institute of Technology (MIT) and radar, the Manhattan Project and the atomic bomb - demonstrated the effectiveness and impact of research-driven industrial development on national security and led to formal recognition of the transformative role of basic science.[93] After WWII, the post-war paradigm of the federal government's central role in funding basic research was established by Vannevar Bush's "Science – The Endless Frontier" in 1945.[94] However, the federal government's ability to translate the growing R&D funding at universities, research institutes, and federal laboratories into "the progress of science and the useful arts" was constrained by the lack of a proper legislative

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[91] William Rosen, *The Most Powerful Idea in the World: A Story of Steam, Industry, and Invention.*
[92] Charles R. Morris, *The Dawn of Innovation: The First American Industrial Revolution.*
[93] Richard Rhodes, *The Making of the Atomic Bomb; Vannevar Bush, Science, The Endless Frontier.* https://www.nsf.gov/od/lpa/nsf50/vbush1945.htm
[94] Vannevar Bush, *Science, the Endless Frontier.* https://www.nsf.gov/od/lpa/nsf50/vbush1945.htm

framework that would facilitate the private sector's ability to develop and commercialize new inventions produced as a result of public funding.

Formally chartered and funded by the Federal Technology Transfer Act of 1986, the Federal Laboratory Consortium for Technology Transfer (FLC) was established to serve as a membership organization of "senior staff" representatives of federal laboratories. Their mission is to carry out, "in cooperation with Federal laboratories and the private sector," such activities as "increasing the awareness of Federal laboratory employees regarding the commercial potential of laboratory technology and innovations," and to "furnish advice and assistance requested by Federal agencies and laboratories for use in their technology transfer programs." The FLC periodically publishes *The Green Book – Federal Technology Transfer Legislation and Policy* which provides an insightful summary of the legislation that exemplifies the continuing efforts to promote technology transfer and to provide technology transfer mechanisms and incentives.[95]

"Since 1980, Congress has enacted a series of laws to promote technology transfer mechanisms and incentives. The objective of these laws, coupled with several executive orders, is to encourage the pooling of resources when developing commercial technologies. The bidirectional sharing between federal laboratories and private industry includes not only technologies, but personnel, facilities, methods, and technical information in general."[96] Several significant pieces of legislation in regards to technology transfer legislation affecting DOE National Laboratories include the Stevenson-Wydler (Stevenson-Wydler Technology Innovation Act of 1980 – Public Law 96-480), the Bayh-Dole Acts (Patent and Trademark Law Amendments Act – Public Law 96-517) (1980), and the Federal Technology Transfer Act of 1986 – Public Law 99-502 (1986).[97] These acts "were transformational for the U.S. when enacted in 1980, providing clarity for intellectual property ownership for the public good, and incentivizing the commercial development of inventions for U.S. economic impact."[98]

- *The Stevenson-Wydler Act* is the first of a continuing series of laws to define and promote technology transfer. It made it easier for federal laboratories to transfer technology to nonfederal parties and provided outside organizations with a means to access federal laboratory developments. The primary focus of the Stevenson-Wydler Act concerned the dissemination of information from the federal government and getting federal laboratories more involved in the technology transfer process. The law also established an Office of Research and Technology Applications (ORTA) in each laboratory to coordinate and promote technology transfer. [99]
- *The Bayh-Dole Act,* together with the Trademark Clarification Act of 1984, established more boundaries regarding patents and licenses for federally funded research and development. Small businesses, universities, and not-for-profit organizations could elect to retain titles to inventions developed with federal funds. Government owned and

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[95] From: The Federal Laboratory Consortium for Technology Transfer, Federal Technology Transfer Legislation and Policy (The Green Book), page 14; United States Code, Title 15, Chapter 63, *Section 3710 "Utilization of Federal Technology"*.
[96] The Federal Laboratory Consortium for Technology Transfer, Federal Technology Transfer Legislation and Policy (The Green Book), x.
[97] 99th Congress, *Public Law 96-480 "Stevenson Wydler Technology Innovation Act of 1980."; 96th Congress, Public Law 96-517 "An act to amend the patent and trademark laws."*
[98] 10.6028/NIST.SP.1234
[99] Ibid.

government operated (GOGO) laboratories were permitted to grant exclusive patent licenses to commercial organizations." [100]

- *Federal Technology Transfer Act* established that all federal laboratory scientists and engineers are required to consider technology transfer to be an individual responsibility, and technology transfer activities are to be considered in employee performance evaluations. Further, the law established a charter and funding mechanism for the previously existing FLC. In addition, the law enabled GOGO laboratories to enter into Cooperative Research and Development Agreements (CRADAs) and to negotiate licensing arrangements for patented inventions made at the laboratories. It also required that government-employed inventors share in royalties from patent licenses. Further, the law provided for the exchange of personnel, services, and equipment among the laboratories and nonfederal partners.[101] Other specific requirements, incentives and authorities were added, including permission for current and former federal employees to participate in commercial development, to the extent that there is no conflict of interest."[102]

Congress demonstrated a consistent interest in advancing technology transfer activities across the federal government and there is particular interest in the activities from DOE. These include the development and commercialization of energy technologies and more recently for clean energy technologies. In chronological order, Box 3.1 lists federal technology transfer legislation that includes the development of technology transfer since 1980.

**Box 3.1: Other Technology Transfer Legislation**

- Small Business Innovation Development Act of 1982 (P.L. 97-219)
- Omnibus Trade and Competitiveness Act of 1988 (P.L. 100-418)
- National Competitiveness Technology Transfer Act of 1989 (P.L.101-189)
- American Technology Preeminence Act of 1991 (P.L. 102-245)
- Small Business Research and Development Enhancement Act of 1992 (P.L. 102-564)
- National Department of Defense Authorization Act for 1994 (P.L.103-160)
- National Technology Transfer and Advancement Act of 1995
- (P.L. 104-113)
- Technology Transfer Commercialization Act of 2000 (P.L. 106-404)
- America COMPETES Act (P.L. 110-69) (2007)
- America Invents Act (P.L. 112-29) (2011)
- The Cooperative Research Act of 1984 (P.L. 98-462)
- The National Institute of Standards and Technology Authorization Act for FY 1989 (P.L. 100-519)
- The Defense Authorization Act for FY 1991 (P.L. 101-510)

[100] The Federal Laboratory Consortium for Technology Transfer, Federal Technology Transfer Legislation and Policy (The Green Book), x.
[101] *Ibid*, xi.
[102] From: The Federal Laboratory Consortium for Technology Transfer, Federal Technology Transfer Legislation and Policy (The Green Book), page 14; United States Code, Title 15, Chapter 63, *Section 3710 "Utilization of Federal Technology"*.

While there is an effort in technology transfer legislation across the federal government, the notable examples of legislation that advanced technology transfer activities specifically for DOE include:

- *The Energy Policy Act of 2005*[103]: The first omnibus energy legislation enacted a comprehensive bill with eighteen titles in 551 pages and proposed specific activities at DOE to support technology transfer. Notable requirements include:
    - A technology transfer coordinator as the principal advisor to the Secretary on all matters related to technology transfer and commercialization;
    - A technology transfer working group to coordinate technology transfer activities at the DOE labs (with oversight by the technology transfer coordinator); and
    - An energy technology commercialization fund to provide matching funds with private partners to promote energy technologies for commercial purposes.
- *The Department of Energy Research and Innovation Act of 2018*[104]: Title I – Laboratory Modernization and Technology Transfer Act, provides a "Sense of Congress on Accelerating Energy Innovation," which states that "accelerating the pace of clean energy innovation in the United States calls for:
    - Supporting existing research and development programs at the Department and world-class National Laboratories.
    - Exploring and developing new pathways for innovators, investors, and decision-makers to leverage the resources of the Department for addressing the challenges and comparative strengths of geographic regions… [including] a regional approach to innovation can bridge the gaps between local talent, institutions, and industries to identify opportunities and convert United States investment into domestic companies."

Legislation including these provisions provide greater authority and flexibility to the DOE National Laboratories and lab directors; creating a research grants database; specifying criteria for existing pilot programs such as Agreements for Commercializing Technology, Innovation Hubs, and Energy Frontier Research Centers; and creating a two-year pilot program eliminating cost sharing requirements for nonprofit organizations and universities.

Legislative guidance for technology transfer activities is additionally written in several House and Senate Energy and Water Appropriations Subcommittee Reports. Congress indicated a strong interest in supporting the full spectrum of research, development, demonstration, and deployment activities. The Senate Appropriations FY 2020 Subcommittee Report states, "The Department is directed throughout all of its programs to maintain a balanced portfolio of early-, mid-, and late-stage research, development, and market transformation activities that will deliver innovative energy technologies practices, and information to American consumers and

[103] 109th Congress, Public Law 109-58 "The Energy Policy Act of 2005". https://www.congress.gov/bill/109th-congress/house-bill/6/text
[104] 115th Congress, Public Law 115-246 "Department of Energy Research and Innovation Act". https://www.congress.gov/bill/115th-congress/house-bill/589/text

industry."[105] The House Appropriations FY 2020 Subcommittee Report states "The Committee provides robust funding to support a comprehensive, balanced approach that also includes medium- and later-stage research, development, deployment and demonstration activities.[106]

## 3.2 Definition of Technology Transfer

The preceding section described the rich legacy of legislation that directs technology transfer activities and provides the legal framework that governs DOE activities. The Study Team observed that the traditional view of technology transfer that underlies the legislation reflects the linear model articulated by Vannevar Bush, in which publicly funded basic research leads to privately funded commercial applications.[107] This viewpoint suggests a specific and perhaps narrow channel within which a foundation may add value. This section explores a more expansive definition of technology transfer while the following chapter explores technology as innovation.

The Study Team recognizes the need to utilize a broad and inclusive working definition of technology transfer to categorize and analyze DOE's efforts in the domain, consistent with the definitions cited below. Principal components of technology transfer include, but are not limited to, the existing knowledge, facilities, capabilities, scientific discoveries, and knowledge developed under federal research and development, which are utilized to fulfill public and private sector need.[108] The widely accepted concept of technology transfer has evolved over the past four decades and reflects a broad and inclusive understanding of the ways the knowledge, facilities, and technologies are diffused, disseminated, and deployed for public benefit. Illustrative examples of this technology transfer framing are:

- *DOE's Office of Technology Transitions:* "The Mission of the Office of Technology Transitions is to expand the public impact of the department's research and development (R&D) portfolio to advance the economy, energy and national security interests of the nation."[109]
- *The Federal Laboratory Consortium*: "Technology transfer is the process by which existing knowledge, facilities or capabilities developed under federal research and development (R&D) funding are utilized to fulfill public and private need."[110]
- *The U.S. Department of Agriculture*: "Technology transfer [is] the adoption of research outcomes (i.e., solutions) for public benefit."[111]
- *The National Institute of Standards and Technology (NIST):* "Technology Transfer is the overall process by which NIST knowledge, facilities or capabilities in measurement

[105] U.S. Senate Appropriations Committee, Conference Report on the Energy and Water Development Appropriations Bill, 2020, page 69. https://www.congress.gov/congressional-report/116th-congress/senate-report/102/1
[106] U.S. House of Representatives Appropriations Committee, Conference Report on the Energy and Water Development and Related Agencies Appropriations Bill, 2020. https://www.congress.gov/congressional-report/116th-congress/house-report/83/1
[107] Vannevar Bush, *Science, the Endless Frontier*. https://www.nsf.gov/od/lpa/nsf50/vbush1945.htm
[108] The Study Team adopted a broad concept of technology transfer, consistent with current writing and practice in the field, and in accordance with interviews with DOE staff.
[109] United States Department of Energy, Office of Technology Transitions, Mission. https://www.energy.gov/technologytransitions/mission-0
[110] Federal Laboratory Consortium for Technology Transfer, *FLC Technology Transfer Desk Reference*. https://federallabs.org/sites/default/files/reference_downloads/desk-reference-6th-edition-official_0.pdf
[111] National Institute of Standards and Technology, Agency Technology Transfer Reports. https://www.nist.gov/tpo/reports-and-publications/reports

science, standards, and technology promote U.S. innovation and industrial competitiveness to enhance economic security and improve quality of life."[112]

- *DOE National Laboratory Directors Council (NLDC):* In a July 2018 formal response to NIST's "Return on Investment Green Paper" Request for Information, DOE's NLDC provided the following definition:

  "*Agency emphasis on, and support for, technology transfer is a significant driver of success at the DOE National Laboratories. We define technology transfer in the broad sense as the process of transferring scientific discoveries, technologies and authored works from our laboratories to other organizations for the purposes of furthering research, development and/or for commercialization to benefit the U.S. The DOE National Laboratories use many pathways to carry out this responsibility, including: (a) publication of our research efforts; (b)hosting scientific users at our cutting-edge user facilities; (c) conducting research and development activities with industry, academia, and others; (d) exchange of personnel via joint appointments with academia or industry exchange; licensing of patents and copyrights secured through our research efforts: (f) creation or support of start-up businesses that help to move our early stage science and technology into commercial application; and (g) novel commercialization mechanisms sponsored by the DOE that leverage the use of laboratory expertise such as the Small Business Voucher Program, the Lab Embedded Entrepreneurship Program, and the Technology Commercialization Fund." [113]*

- *The Thomas Jefferson National Accelerator Facility:* Jefferson Science and Southeastern Universities Research Association provide an insightful discussion of the length of time to realize the commercial benefits of research and development. They state in response to NIST's RFI:

  *"Research valuation is difficult because benefits are often unanticipated or unforeseen and may not be realized until the distant future. An example is Albert Einstein's work on relativity more than a century ago to explain the relationship of space, time, and gravity. The first patented technology from this research came not from the former patent examiner, presumably because he did not envision an immediate commercial application. It was an invention of Ernest Lawrence for the particle accelerator, an instrument now extensively used in research, materials processing, and medicine… The particle accelerator and GPS systems are examples of unanticipated and unforeseen benefits of relativity research and have further led to new fields of research unimaginable to Einstein."[114]*

- *The National Bureau of Economic Research (NBER):* A more inclusive concept of federal technology transfer, in the context of innovation, is presented in a recent NBER working paper, "Innovation in the U.S. Government," which identified four types of "government innovations": "technological innovation," "organizational innovation," "regulatory

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[112] National Institute of Standards and Technology, *Annual Report on Technology Transfer: U.S. Department of Commerce.* https://www.nist.gov/system/files/documents/2019/10/17/fy2018_doc_tt_final.pdf
[113] *Source: National Institute of Standards and Technology, Return on Investment Initiative, Final Green Paper, page 105.*
[114] *National Institute of Standards and Technology, Return on Investment Initiative, Final Green Paper, page 104.*

innovation," and "policy innovations," and stated that "technically new and novel inventions and improvements," the common definition of innovation represent "only a fraction of all innovation that is conducted by the U.S. government."[115] The authors note that patents are only one measure of innovation and point to publications, prizes, and the role of government as a lead user as other important vectors of innovation.

## 3.3 DOE & Cross-Agency Priority Goals and Strategic Goals Related to Technology Transfer

### *3.3.1 President's Management Agenda Cross-Agency Priority Goals*

DOE participates in three Cross-Agency Priority Goals (CAP Goals) within the President's Management Agenda (PMA) which implicitly reflects a broad conception of technology transfer including the Workforce for the 21st Century, Category Management: Security and Protection, and to Improve Transfer of Federally Funded Technologies from Lab-to-Market. A further description of the goals includes:[116]

- Workforce for the 21st Century: The CAP Goal statement for workforce reads, "Effective and efficient mission achievement and improved service to America through enhanced alignment and strategic management of the Federal workforce." In 2020, DOE was a sub-goal team member for, "improving employee performance management and engagement and reskilling and deploying human capital resources."

- Category Management: Security and Protection: DOE is responsible for leveraging common contracts and best practices to drive savings and efficiencies in the security and protection category.

- Improve Transfer of Federally Funded Technologies from Lab-to-Market: "Agencies under this CAP Goal are instructed to implement improvements through reducing the administrative and regulatory burdens for technology transfer and increasing private sector investment in later-stage [research and development]."[117]

DOE made significant strides to direct labs to develop more effective partnering models and to improve their methods for evaluating the return on investment and the economic and national security impacts of federally funded research and development. This was evident during the execution of these CAP Goal. DOE permanently established Agreements to Commercialize Technology (ACT), developed a streamlined partnering process through laboratory initiated and DOE approved master scopes of work, reduced administrative and regulatory burdens by assessing and implementing a risk-based policy approach to liability provisions in tech transfer mechanisms, created the Lab Partnering Service, and hosted the cybersecurity technology showcase to further the Lab-to-Market CAP Goal. In 2018, DOE submitted to the Lab-to-Market

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[115] National Bureau of Economic Research, *NBER Working Paper Series: Innovation in the U.S. Government.* https://www.nber.org/system/files/working_papers/w27181/w27181.pdf

[116] United States Office of Management and Budget and General Services Administration, Cross-Agency Priority Goals. https://www.performance.gov/about/CAP_about.html

[117] *Ibid.*

Subcommittee of the National Science and Technology Council (NSTC) a listing of 85 commercialization initiatives (See Appendix I: Additional Information Regarding Technology Transfer, DOE Commercialization Initiatives).

This section provides insight of DOE's efforts to increase technology transfer mechanisms across the agency and with other agencies. This is evident in the achievements that DOE has made in implementing the President's Management Agenda's Cross-Agency Priority Goals and technology transfer strategic goals.

### *3.3.2 DOE Strategic Goals, Objectives, and Priorities*

DOE enumerates strategic objectives and priorities related to technology transfer. DOE's Strategic Plan for FY 2014-2018 is the most recently published strategic planning document released by the Department (the 2018-2022 Strategic Plan is currently under review by OMB).[118] DOE's 2014-2018 Strategic Plan contains two main strategic objectives that support a broad definition of technology transfer.

- *Strategic Goal 1: Science and Energy*
    - *Strategic Objective 1* directs DOE's constituent structure to support the "prudent development, deployment, and efficient use of… energy resources that also create new jobs and industries."
- *Strategic Goal 3: Management and Performance*
    - *Strategic Objective 3* is to "deliver the scientific discoveries and major scientific tools that transform our understanding of nature and strengthen the connection between advances in fundamental science and technology innovation."
    - *Strategic Objective 12* is also aligned with tech transfer as it relates to human capital to "attract, manage, train, and retain the best federal workforce to meet future mission needs."

In its 2019 report, DOE's Office of Technology Transitions presented DOE's strategic priorities for FY 2021 which included a provision for an active focus on technology transfer. Within the report, it states "technology transfer is an active focus of DOE's efforts to promote scientific and technological innovation that advances the economic, energy, and national security interests of the United States."[119] Further, DOE's strategic priority related to technology transfer for FY 2021 is the commercial adoption of energy technologies.[120]

The Office of Technology Transitions is tasked to "enable increased commercial adoption and use of the broad suite of technologies and facilities developed and maintained by [DOE] through enhanced public-private and public-public partnerships. By September 30, 2021, expand

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[118] U.S. Department of Energy, Strategic Plan for Fiscal Years 2014-2018.
https://www.energy.gov/sites/prod/files/2014/04/f14/2014_dept_energy_strategic_plan.pdf
[119] U.S. Department of Energy Office of Technology Transitions, *Report on the Utilization of Federal Technology: Fiscal Years 2016 and 2017*, 1.
[120] U.S. General Services Administration and Office of Management and Budget, *Department of Energy*. "Commercial Adoption of Energy Technologies," Government, Department of Energy, September 17, 2020.
https://www.performance.gov/energy/APG_energy_1.html

engagement efforts to private and other federal entities and create tailored opportunities and products to simplify access to DOE's portfolio of facilities, technologies, and world-leading experts."

The two preceding sections presented perspectives on the more contemporary definitions of technology transfer from a variety of organizations, including USDA, NIST, professional associations such as the FLC, and DOE offices, and representatives of the National Laboratories. The sections also summarized a government wide framing of the concept and the alignment of DOE's activities within that President's management goals. The next section describes DOE's technology transfer activities and outputs, as prescribed in statutory authority, and based upon currently available data.

## 3.4 DOE Technology Transfer Data

This section reviews DOE technology transfer data and activities. The Study Team focused on publicly available data on DOE technology transfer activities, including information reported by NIST and NSF, analyses presented in studies and reports, and material provided by DOE to the Academy. This review presents a mosaic of metrics that provide perspective on the level of DOE tech transfer activities that established a data-based benchmark for identifying the potential value of a DOE affiliated foundation.

The Study Team prepared a comparative analysis of technology transfer metrics between DOE and to other federal agencies. Data for DOE were summarized in the annual report pursuant to U.S.C. Title 15, Section 3710 (g)(2). NIST created a report that summarizes agency reported data for federal invention disclosures and patenting, federal licenses and license income, cooperative research and development agreements, small business participation in collaborative agreements and in licenses, and start-ups (companies under five years that "received critical technical support from federal laboratories"). The most recent data available from FY2016 is displayed below in Figure 3.1. The technology transfer metric data is extensive; however, it is aggregated at the agency level, including in the case of DOE, from the National Laboratories, sites, and plants, not at sub-units, such as Program Offices or Labs.

The report created by NIST only presents information on R&D activities conducted by federal employees such as at NETL (defined by NIST as "intramural") and by contractors at the 16 DOE FFRDCs, and other facilities. The data does not include other federally funded R&D, performed by industry, universities and colleges, other nonprofits, state and local governments, and foreign entities through financial assistance awards. According to NSF, in FY2018, DOE's federal obligations for R&D by these performers equaled $3.419 billion, 29.5 percent of the total of $11.601 billion.

Examples of DOE's "extramural" funding activities or activities conducted beyond federal employees will be presented in a later section of this chapter.

**Figure 3.1: Federal Obligations for R&D by Agency for FY 2016 (dollars in millions)**

**Federal Obligations for R&D**
**By Agency FY 2016 ($ million)[5]**

| | Total R&D | Intramural[(a)] | FFRDCs[(b)] | Intramural and FFRDCs | Percent of Total R&D Budget |
|---|---|---|---|---|---|
| All Agencies | $115,040 | $32,020 | $11,404 | $43,424 | 38% |
| DoD | $44,749 | $16,864 | $1,703 | $18,567 | 41% |
| DOE | $11,601 | $939 | $7,213 | $8,152 | 70% |
| HHS | $32,216 | $7,123 | $520 | $7,642 | 24% |
| NASA | $12,404 | $1,785 | $1,529 | $3,314 | 27% |
| USDA | $2,358 | $1,538 | $0 | $1,538 | 65% |
| DOC | $1,351 | $1,055 | $13 | $1,069 | 79% |
| DOI | $857 | $749 | $1 | $750 | 88% |
| VA | $695 | $695 | $0 | $695 | 100% |
| DOT | $937 | $253 | $77 | $331 | 35% |
| DHS | $532 | $186 | $89 | $276 | 52% |
| EPA | $508 | $255 | $2 | $258 | 51% |
| Other Agencies | $6,834 | $576 | $256 | $832 | 12% |

(a) Intramural activities cover costs associated with the administration of intramural and extramural programs by federal personnel as well as actual intramural performance.
(b) FFRDC = federally funded research and development center

(Source: The National Institute of Standards and Technology).[121]

When the Academy conducted a comparative analysis between DOE's technology transfer metrics and other federal agencies, DOE performs well. Although DOE received only 18.7 percent of total intramural and FFRDC obligations among all agencies, it ranked first in the number of new invention disclosures, patent applications, issued patents, active licenses, and income bearing licenses, and was second in invention licenses to HHS. In the number of active licenses granted to small businesses, DOE ranked first, and ranked second in the number of active cooperative agreements with small businesses.[122]

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[121] National Institute of Standards and Technology, *Federal Laboratory Technology Transfer: Fiscal Year 2016*. Appendix E presents the analysis. Intramural research is performed by scientists employed by the Federal Government. Intramural activities cover costs associated with the administration of intramural and extramural programs by federal personnel as well as actual intramural performance. Extramural research includes activities that occur outside of federal laboratories, and encompass grants, cooperative agreements, and similar agreements.
[122] The total number of start-ups reported by the federal agencies in 2016 was 100, and DOE reported no activity, but as the report noted, "few [agencies] have established systematic methods to identify and track the startup companies they are working with." *Ibid*, 20.

The tables below illustrate DOE's performance as compared to other federal agencies. See the Appendix I: Additional Information Regarding Technology Transfer, Selected Agency Technology Transfer Metrics for FY 2016 for a more complete set of the tables:[123]

**Figure 3.2: DOE Technology Transfer Performance Compared to Other Agencies**

**New Invention Disclosures (2016)**

| | | |
|---|---|---|
| DOE | 1760 | 35% |
| NASA | 1554 | 31% |
| DoD | 874 | 17% |
| HHS | 320 | 6% |
| USDA | 244 | 5% |
| **Selection Total** | **4752** | **93%** |
| **All Agencies** | **5086** | **100%** |

[123] National Science Foundation, *Survey of Federal Funds for Research and Development Fiscal Years 2018-19.* https://ncsesdata.nsf.gov/fedfunds/2018/index.html

**Patent Applications (2016)**

| | | |
|---|---|---|
| DOE | 999 | 38% |
| DoD | 941 | 36% |
| HHS | 269 | 10% |
| NASA | 129 | 5% |
| USDA | 109 | 4% |
| **Selection Total** | **2447** | **94%** |
| **All Agencies** | **2596** | **100%** |

**Patents Issued (2016)**

| | | |
|---|---|---|
| DOE | 856 | 37% |
| DoD | 665 | 28% |
| HHS | 579 | 25% |
| NASA | 103 | 4% |
| USDA | 60 | 3% |
| **Selection Total** | **2263** | **97%** |
| **All Agencies** | **2341** | **100%** |

**Active Licenses (2016)**

| | | |
|---|---|---|
| DOE | 5410 | 60% |
| HHS | 1750 | 20% |
| DoD | 515 | 6% |
| NASA | 452 | 5% |
| USDA | 441 | 5% |
| **Selection Total** | **8568** | **96%** |
| **All Agencies** | **8950** | **100%** |

**Income Bearing Licenses (2016)**

| | | |
|---|---|---|
| DOE | 3963 | 68% |
| HHS | 837 | 14% |
| USDA | 439 | 8% |
| NASA | 245 | 4% |
| DoD | 194 | 3% |
| **Selection Total** | **5678** | **98%** |
| **All Agencies** | **5804** | **100%** |

In 2011, the Institute for Defense Analyses' Science and Technology Policy Institute (STPI) provided an additional perspective on the level of technology transfer activity in a Memorandum accompanying the release of its report on Federal Laboratory Technology Transfer.[124] The report is consistent with the Academy's analysis of FY 2016; over the period of 1988-2008, DOE ranked first in invention disclosures, patent applications and licenses, second to DoD in patents issued, and second to HHS in license income. The report normalized metrics to intramural R&D dollars and commented that "DOE, NASA, and VA produce substantially more invention disclosures per intramural R&D dollar than the other agencies and the data reveal that DOE is ranked first in patent applications, patents issued, licenses, and second only to HHS in terms of license income on a normalized basis.[125]

**Private Sector Partnering**

The DOE National Laboratory system consists of both Government-owned, government-operated (GOGO) facilities and government-owned, contractor-operated (GOCO) facilities. While the GOGO is owned or leased by the United States Government and managed and primarily staffed by employees of the federal government, GOCOs are owned or leased by the United States Government but managed by third-party contractors. Within the GOCO system, Federally Funded Research and Development Centers (FFRDC) are designed to meet a special long-term research and development need that could not be met as effectively by existing in-house or contractor resources.[126]

Although a variety of DOE entities perform R&D, the distinguishing characteristics of DOE's National Laboratory system are the activities of FFRDCs which have been central to DOE's business model, whose origins lie in the WWII Manhattan Project. [127] The authorities provided to an FFRDC contractor include the ability to use private-sector resources to accomplish tasks that are integral to its mission and operation so the GOCO can adjust quickly to provide new and cutting-edge scientific support and technical expertise. Of the 17 DOE National Laboratories and cumulative 42 government wide FFRDCs in 2019, 16 labs are FFRDCs. This unique system is the largest single contingent within any agency. And in 2016, the funding for DOE's FFRDC's represent 70 percent of the agency's federal R&D obligations, and 88 percent of the agency's total intramural and FFRDC obligations.

In a 2009 study of technology transfer, GAO reported that DOE generally recognized four primary types of activities that are widely regarded as technology transfer: cooperative research and development, work for others (WFO), licensing, and user-facility agreements, and reported on the number of projects and contributed funds for FY2008 by laboratory.[128] The study reported:

- 626 CRADAs with private partners with $69.3 million in Partner-Contributed funds;

[124] Institute for Defense Analyses' Science and Technology Policy Institute, *Memorandum: Federal Laboratory Technology Transfer and Commercialization Metrics: Alternative Presentation Approaches.*
[125] Italicized text in quote added by the Academy.
[126] Belinda Snyder and Jeffrey Thomas, *GOGOs, GOCOs, and FFRDCs… OH MY!.* https://federallabs.org/sites/default/files/reference_downloads/federal-laboratory-designations__0.pdf
[127] *The Origin, Characteristics, and Significance of the Department of Energy's Management and Operating (M&O) Form of Contract –Acquisition Guide*
[128] Technology Transfer – Clearer Priorities and Greater Use of Innovative Approaches Could Increase the Effectiveness of Technology Transfer at Department of Energy Laboratories (GAO –09-548), Appendix II, 37-41. Note that WFO is currently referred to as "SPP."

- 1,694 WFO agreements with private partners with $137.8 million in Partner-Contributed funds;[129]
- 1,504 patent licenses with private partners with $43.8 million in Revenues; and
- 783 user facility agreements with private partners with $6.4 million in Revenues.

The lab level data displayed in the report revealed that there is significant variation in the use of different mechanisms across the labs, along with a concentration of usage of some tools among certain labs. For example, four Labs account for 63 percent of all licenses, and four Labs account for 66 percent of federal WFO (currently SPP) agreements. Although the Labs differ in mission, and by whether defense or non-defense, applied or basic, multi-purpose or single purpose, all labs participate in CRADAs with private partners, in WFO with private partners, and have license agreements with private partners. In the case of user-facility agreements with private partners, eight labs with accessible facilities participate, including both Office of Science and NNSA labs.

Other publicly available information provides a more recent and detailed view of the participation of non-federal stakeholders in DOE technology transfer mechanisms. A chart included in a November 2017 OTT presentation on "Agreements for Commercializing Technology" (See Appendix I: Additional Information Regarding Technology Transfer, DOE Agreements to Commercialize Technology) reveals the extensive use of Strategic Partnership Projects (SPPs) by Non-Federal Entities:

- College/University (>650)
- Large Business (575)
- Small Business (350)
- Not-for-Profit (>200)
- State/Local U.S. Government (150)

It also reveals the use of CRADAs by:

- Large Business (>275)
- Small (>200) Business during FY2014-2016. [130]

In addition to the metrics that DOE displays to NIST, DOE's Office of Technology Transitions (OTT) annually collects 80 metrics from the 17 National Laboratories and four security sites and plants (See Appendix I: Additional Information Regarding Technology Transfer, National Laboratory Metrics, Sites and Plants). This data set provides the diversity of technology transfer mechanisms utilized by DOE. The extent, detail, and quality of this information provide excellent

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[129] The bulk of WFO dollars are from other federal agencies which provided $1.866 billion in 4,4978 projects. GAO 2009 09-546 study found that in 2008 other federal agencies provided sponsor-contributed funds totaling $1.866 billion through 4,978 agreements, but that "DOE and Laboratory officials do not agree, however, on whether research sponsored by other federal agencies should be considered technology transfer, and DOE's policies are unclear on this.
[130] U.S. Department of Energy Office of Technology Transitions, *Report on the Utilization of Federal Technology: Fiscal Years 2016 and 2017*. Appendix E, Table 2

groundwork for further policy analysis and program development. The metrics are organized into the ten major categories shown in box 3.2:[131]

**Box 3.2: Ten Technology Transfer Categories**

- CRADAs;
- Income Bearing Licenses;
- Non-Income Bearing Licenses;
- Software Licenses;
- License (Income);
- Intellectual Property;
- Strategic Partnership Projects (formerly WFO);
- User Facility Data;
- Science Education Activities Performed;
- Other Data Elements.

The tables below summarize selected metrics, highlighting the participation of small businesses with DOE in CRADAs, licenses, SPPs, user facilities, and other collaborative activities. While the data in the NIST report demonstrates that DOE compares favorably to other agencies in small business participation, the granular DOE data suggests that an opportunity exists for greater engagement with very small business, i.e., below the SBA's definition of small business as containing fewer than 500 employees.

**Figure 3.3: National Lab, Sites, and Plants, Selected Utilization Metrics – FY 2018**

| Total CRADAs | Total CRADAs with Small Businesses |
|---|---|
| Total | Total |
| 979 | 434 |

[131] Guidance to the Labs on reporting is provided in the "Department of Energy Technology Transfer Working Group Reporting and Appraisal Guide for DOE Technology Transfer Activities".

| Total Active Licenses | Total Licenses Granted to Small Businesses |
|---|---|
| Total | Total |
| 4742 | 169 |

| Strategic Partnership Projects | |
|---|---|
| Total Agreements | Total Agreements with Small Business Sponsors |
| 2246 | 485 |

| User Facility Data: Projects | | |
|---|---|---|
| User Projects Awarded | User Projects Awarded to Small Businesses | User Projects Awarded to Industry |
| 16209 | 189 | 298 |

(Created by the National Academy of Public Administration)

The preceding section's discussion of DOE tech transfer data offers a data-based analysis on DOE's level of tech transfer activity. The Study Team observed that tech transfer at DOE, as measured by traditional metrics, compares favorably to other agencies. It is also noted that the DOE Labs (GOCO and GOGO) and other facilities, such as sites and plants are propelling this activity. The robust level of participation by external parties through technology transfer mechanisms such as CRADAs, SPPs, patent licenses, and user facility agreements, and the engagement by most Labs demonstrates buy-in at the operating level. Further, the Academy recognizes the depth and scope of rich data collected by the Office of Technology Transitions (OTT) as a valuable tool in advancing DOE's activity and identifying new opportunities. One such opportunity is the increased engagement of very small (< 50 employees) companies with DOE.

### 3.5 Summary of DOE's Technology Transfer Initiatives

DOE developed and implemented several programs, initiatives, and mechanisms to facilitate the transfer of innovative technologies from its National Laboratories to the commercial markets. An inventory of DOE commercialization activities prepared by the 2018 Lab-to-Market Subcommittee of the NSTC may be found in Appendix I: Additional Information Regarding Technology Transfer, DOE Commercialization Initiatives of this report. These initiatives and programs are executed at the laboratory level and employ a broad array of approaches toward achieving the Department's goals in the realm of technology transfer. Box 3.3 presents a selection of technology transfer initiatives.

**Box 3.3: Selected Technology Transfer Initiatives**

1. Technology Commercialization Fund (TCF)
2. Lab Partnering Service (LPS)
3. Lab Embedded Entrepreneurship Programs
4. Energy I-Corps
5. Technologists in Residence (TIR)
6. Small Business Vouchers (SBV) Program
7. Strategic Partnership Projects (SPPs)
8. Agreement for Commercializing Technology (ACT)
9. Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR)
10. Manufacturing Demonstration Facility (MDF)

DOE's suite of technology transfer initiatives is utilized to:[132]

- Encourage public-private partnerships and leverage private dollars in key stages of the technology maturation cycle;
- Pair National Laboratory expertise, capabilities, and facilities with external partners;
- Increase awareness and accessibility of National Laboratory expertise and capabilities;
- Provide entrepreneurial training to promising inventors at the National Laboratories;
- Facilitate high-risk, high-return research projects on the DARPA model at the Advanced Research Projects Agency – Energy;
- Improve advanced materials and infrastructure;
- Assist small businesses with technical needs, and incentivize small businesses to develop new technologies; and
- Streamline contracting and partnership processes with external stakeholders.

Many of the aforementioned programs and initiatives are DOE initiated programs, while others such as the Technology Commercialization Fund were created or congressionally authorized in federal legislation. An expanded discussion of DOE's programs, initiatives, and mechanisms related to the facilitation of technology transfer are provided in Appendix E of this report.

### *3.5.1 DOE "Extramural" Programs – (R&D Performed by Universities, Private Sector, Not-for-Profits, State and Local Governments, and Foreign Entities)*

A review of technology transfer activities funded through financial assistance awards (e.g., grants), performed by non-DOE entities such as universities, private industry, non-profits, state and local governments, and foreign entities is instructive to further understand DOE's full technology transfer portfolio and output. The relationship between DOE and these entities mirrors the DOE-National Lab relationship, exhibiting close management and oversight, robust technical interchanges, careful monitoring, and tracking traditional tech transfer outputs.

[132] United States Congress, *Energy Policy Act of 2005*. https://www.congress.gov/109/plaws/publ58/PLAW-109publ58.pdf; U.S. Department of Energy Office of Technology Transitions, *Technology Commercialization Fund*. https://www.energy.gov/technologytransitions/initiatives/technology-commercialization-fund; U.S. Department of Energy Office of Technology Transitions, *Lab-Embedded Entrepreneurship Programs*. https://www.energy.gov/eere/amo/lab-embedded-entrepreneurship-programs; U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, *AMO LEEP Overview 2019*.; U.S. Department of Energy Office of Technology Transitions, *Energy I-Corps*. https://www.energy.gov/technologytransitions/energy-i-corps; U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, *Technologist in Residence Program*. https://www.energy.gov/eere/amo/technologist-residence-program; U.S. Department of Energy Office of Technology Transitions, *Report on the Utilization of Federal Technology: Fiscal Years 2016 and 2017*.; U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, *Small Business Vouchers*. https://www.energy.gov/eere/technology-to-market/small-business-vouchers; U.S. Department of Energy, Order 481.1D: *Strategic Partnership Projects*. https://www.directives.doe.gov/directives-documents/400-series/0481.1-BOrder-d/@@images/file; U.S. Department of Energy Office of Technology Transitions, *Lab Partnering Service*. https://labpartnering.org/; U.S. Department of Energy Office of Science, *Small Business Innovation Research and Small Business Technology Transfer*. https://www.energy.gov/science/sbir/small-business-innovation-research-and-small-business-technology-transfer; U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, *Manufacturing Demonstration Facility (MDF) at oak Ridge National Laboratory*. https://www.energy.gov/eere/amo/manufacturing-demonstration-facility-mdf-oak-ridge-national-laboratory

However, when discussing DOE's overall technology transfer program, the scale of these activities is generally not defined as technology transfer outcomes. This understates the full measure of DOE R&D mission supporting efforts and limits the understanding of the potential scope of a foundation.

The scale of extramural technology transfer activities is provided by NSF. In their report, DOE's federal R&D obligations in FY2018 totaled $12.832 billion, of which $3.995 billion is defined as "extramural" funding, approximately 31 percent of the total (consistent with the 2016 NIST report of 29.5 percent). The box below displays the summary of DOE's overall R&D obligations by sector.

**Box 3.4: Federal Obligations for Research and Development, by Agency and Performer: FY 2018**
**(Dollars in millions)**

| | |
|---|---|
| **Total R&D** | 12,832.4 |
| **Intramural, FFRDCs, GOCO** | |
| **Intramural**[a] | 1,336.0 |
| **Industry-administered FFRDCs** | 3,058.1 |
| **University-administered FFRDCs** | 2,222.7 |
| **Nonprofit-administered FFRDCs** | 2,220.7 |
| **Extramural** | |
| **Industry** | 2,375.1 |
| **Universities and colleges** | 1,350.1 |
| **Other nonprofits** | 199.1 |
| **State, local governments** | 69.0 |
| **Foreign** | 1.5 |

(Source: The National Science Foundation. See Appendix I: Additional Information Regarding Technology Transfer, DOE Obligations for Research and Development for greater detail.)

Extramural activities outside of the activities bound by federal laws and policies directed to the federal government and its agencies account for a significant technology transfer activity. These extramural organizations often have a similar relationship to the National Lab's relationship with DOE. The following examples illustrate the range of DOE extramural programs, including university led projects funded by the Office of Nuclear Energy; Clean Energy Innovation Institutes funded by EERE's Advanced Manufacturing Office; and projects funded by the Advanced Research Projects Agency-Energy (ARPA-E).

### *3.5.2 Office of Nuclear Energy*

DOE provides funding to universities and university-lab consortia to advance specific DOE missions. In June 2020, the Office of Nuclear Energy announced $65 million to 93 projects in 28 different states. This funding is just the most recent of a continuing large program- since 2009, DOE's Office of Nuclear Energy awarded more than $800 million through competitive opportunities.[133] Under the Nuclear Energy University Program:[134]

- 57 university-led nuclear energy research and development projects received $38.6 million to maintain U.S. leadership in nuclear research;
- 21 university-led projects received $5.7 million for research reactor and infrastructure improvements; and
- Three Integrated Research Projects executed by university-led consortiums (including National Laboratories) received $10.8 million.

Under Energy Enabling Technologies (NEET) Cross Cutting Research Projects:

- Five research and development projects led by DOE Laboratories and U.S. universities received $5 million; and
- One industry, three DOE Laboratory, and three university-led projects will participate in $5 million in support to investigate important nuclear fuel and material applications and will utilize the User Facilities of these Labs.

### *3.5.3 EERE/Advanced Manufacturing Office*

DOE's Advanced Manufacturing Office (AMO) provides funding to R&D Consortia, which advances the agency's mission goals. One of the most widely recognized is the Clean Energy Manufacturing Institutes, funded by EERE's Advanced Manufacturing Office. Part of Manufacturing USA®, these institutes are part of a network of federally funded institutes dedicated to improving U.S. manufacturing competitiveness and promoting a robust and sustainable national manufacturing R&D infrastructure and are public-private partnerships. The intent is to bring together a broad array of public and private organizations to address common energy-related manufacturing challenges through technical projects, workforce development, and supply chain optimization. As of 2020, five Institutes were in operation, and a sixth was in a start-up phase. For a summary on the Institutes, see Appendix I: Additional Information Regarding Technology Transfer, DOE Manufacturing Institutes.

Collectively the six Institutes represent an initial five-year DOE commitment of $420 million, leveraging $498 million in non-federal commitments. As presented in the Manufacturing USA FY2018 Annual Report, the five operational Institutes had a total of 449 members, representing manufacturing firms, educational institutions, federal, state, and local governments, federal laboratories, and not-for-profit organizations. Funding for the Institutes is through "cooperative agreements," a type of grant that allows substantial involvement for the federal partner. AMO Program Management of the Institutes is robust, including:

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[133] United States Department of Energy, Department of Energy Invests $65 Million at National Laboratories and American Universities to Advance Nuclear Technology. https://www.energy.gov/articles/department-energy-invests-65-million-national-laboratories-and-american-universities

[134] Technology transfer metrics resulting from R&D performed by academic institutions are reported on a voluntary basis to the Association of University Technology Managers – AUTM – a professional association analogous to the FLC. Such reports do not identify specific federal agency funding sources.

- Approval of key operational plans, key personnel, members, IP management plans, sustainability plans, and regular meetings with Consortia Leadership;
- Negotiate SOPO and budgets for each budget period with Go/No-Go decision points;
- Regular meetings with Consortia Technical Leadership and project teams;
- Seats on all Institute Governance Board and appointment of other Federal Representatives;
- Quarterly Assessments;
- Annual Consortia Peer Review;
- Cooperative agreement monitoring and modifications;
- Coordination with EERE contracting, legal, NEPA; and
- Invoice review/approval.

AMO reports on the progress of program activities for both technical projects and workforce activities.[135] In early 2020, AMO began tracking more traditional technology transfer metrics, such as patents, peer-reviewed journal articles, and number of licensed technologies.

AMO's Institute Program Management regime is comparable to the very rigorous system employed by DOE Program Offices in their oversight of National Laboratories, thereby benefitting from DOE's extensive technical expertise. In a similar manner to the National Laboratories, the Institutes compete and cooperate amongst themselves. Although the analogy between the Institutes and Labs is not perfect, a national DOE foundation that serves the Labs can also provide useful support for the Institutes as well.

### *3.5.4 Advanced Research Projects Agency-Energy (ARPA-E)*

The Advanced Research Projects Agency-Energy (ARPA-E) was established in the America COMPETES Act of 2007 (Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science).[136] Modeled on the widely heralded Defense Advanced Research Projects Agency (DARPA), ARPA-E has the mission "to catalyze[s] transformational energy technologies to enhance the economic and energy security of the United States…and funds high-potential, high-impact energy projects that are too risky to attract private sector investment."[137] ARPA-E operates as a public "seed fund," utilizing rigorous program design, competitive project selection, and hands-on engagement to provide energy researchers with

[135] United States Department of Energy, Advanced Manufacturing Office, AMO 2020 Peer Review. https://www.energy.gov/eere/amo/events/amo-2020-peer-review

[136] Advanced Research Projects Agency-Energy (ARPA-E) was created following a recommendation by the National Academies in the "Rising Above the Gathering Storm" report, (2007).

[137] United States Department of Energy, Fiscal Year 2021 Congressional Budget Justification, Volume 2 315. https://www.energy.gov/cfo/downloads/fy-2021-budget-justification

funding through financial assistance awards, primarily cooperative agreements, on-going technical assistance, and market awareness.[138]

ARPA-E practices a robust project management regimen, analogous to the oversight that DOE exercises with its M&O contractors and Innovation Institutes. These techniques include rigorous project selection, similar in some respects to a private venture fund, quarterly reviews against technical, financial, and budget goals, and regular visits to projects. ARPA-E utilizes its growing Tech-to-Market team to function as strategic and business advisors to the projects. ARPA-E annually hosts an Energy Innovation Summit to bring together leaders from academia, government, and business. The 2018 event drew nearly 1,800 attendees and featured over 100 speakers and keynote addresses. ARPA-E tracks performance for five years after project completion, using both project responses and public databases.

As reported in the FY2018 Annual Report, since 2009, ARPA-E awarded $1.971 billion to 864 projects, an average of $2.281 million, generally ranging from just under $1 million to $5 million. In a more recent report, ARPA-E states that since 2009 it has awarded $2.4 billion to 875 projects; selected impacts are:[139]

- 166 projects leveraged $3.3 billion in private sector follow on funding;
- 86 companies were founded by ARPA-E projects;
- 229 projects partnered with other government agencies;
- 609 patents issued; and
- 4,021 peer-reviewed journal articles published

A report completed in June 2017 by the National Academies of Science, Engineering and Medicine (NASEM) provides an independent assessment of the impact of the agency over its first year of operation. ARPA-E's budget regularly increased since inception; in FY 2020 the enacted budget is $425 million, of which $390 is for projects and $35 for program direction.[140]

### *3.5.5 Survey of DOE's Technology Transfer Activities*

The following summary of DOE's technology transfer activities serves as a useful aid to assess where a national DOE foundation could add value. From this analysis, the Academy drew several findings, including:

1. DOE, through its Office of Technology Transitions, annually collects 80 data elements from the National Laboratories and facilities, including activities that reflect a broader concept of technology transfer;

[138] William B. Bonvillian and Richard Van Atta, *Applying the DARPA Model to Energy Innovation*, Chapter 13.; William B. Bonvillian, Richard Van Atta, and Patrick Windham, *The DARPA Model for Transformative Technologies*.
[139] United States Department of Energy Advanced Research Projects Agency-Energy, About, Our Impact. Accessed on September 21st, 2020. https://arpa-e.energy.gov/about/our-impact
[140] United States Department of Energy, Congressional Budget Justification for Fiscal Year 2020, Volume 3 Part 2. https://www.energy.gov/sites/prod/files/2019/04/f61/doe-fy2020-budget-volume-3-Part-2.pdf

2. Compared to other major federal R&D agencies, such as the Department of Defense (DoD), Department of Health and Human Services (HHS), and the National Aeronautics and Space Administration (NASA), DOE performs well in publicly reported technology transfer data;
3. Private sector participation in various mechanisms is high, including by small businesses (<500 employees);
4. A distinguishing characteristic of DOE's approach is the pre-eminent role of the federally funded research and development centers (FFRDC) model in conducting DOE's R&D;
5. DOE has initiated or executed a large number of technology transfer initiatives, including "extramural" programs that are executed outside of the Laboratory structure and amplify the agency's performance;
6. Individual Labs receive funding from numerous DOE Program Offices, from other agencies, from special initiatives, and from non-federal sources which, when combined, creates deep technical capacity in Labs that can be applied to a variety of technical applications, including those not traditionally within DOE's mission, such as the response to Covid-19; and
7. All Labs utilize numerous tech transfer mechanisms, although there is variation according to mission, money, and management.

### 3.6 Summary of Reports and Studies of Technology Transfer at DOE

During the past decade, DOE has been the subject of numerous external, internal and advocacy reports and studies on DOE operations and performance by such organizations as the:[141]

- Bipartisan Policy Center/American Energy Innovation Council (BPC/AEIC);
- Brookings Institution (Brookings);
- Commission to Review the Effectiveness of the National Energy Laboratories (CRENEL);
- Government Accountability Office (GAO);
- Information Technology and Innovation Foundation (ITIF);
- National Academy of Public Administration (The Academy);
- National Academy of Science, Engineering, and Medicine (NASEM); and
- Secretary of Energy Advisory Board (SEAB) National Laboratory Task Force.

A review of this literature reveals several themes that describe the overall federal environment within which DOE technology transfer operates, the distinctive DOE R&D model, challenges, and opportunities for improvement. Understanding this environment provides a context for determining potential roles for a national level DOE foundation. Overarchingly, the reports found

[141] Appendix E contains summaries of selected reports with relevance to DOE technology transfer.

that while DOE performs well in fulfilling its varied missions, its technology transfer impact could be enhanced and achieve effectiveness commensurate with its excellence in science, national security, and environmental activities with organizational and programmatic adjustments. There appears to be both great performance and great potential. Studies selected for review observed that:

- Individual Labs are successfully performing important DOE related missions, and evaluations are measuring key performance elements and holding labs accountable;[142]
- The decentralized, delegated, diverse management model applied to the labs is effective;[143]
- DOE "innovation institutions," such as ARPA-E, and Clean Energy Manufacturing Institutes, leverage DOE's capabilities and expand its technology transfer footprint;[144]
- Start-up activity in clean energy innovation is enhanced by engagements with federal labs;[145] and
- Demand-pull incentives such as public procurement programs and tax credits are a necessary complement to technology push mechanisms to scale-up innovative energy technology.[146]

However, areas for improvement are noted below:

- Realizing the full potential of the labs requires a much greater effort to tap their capabilities, especially in support of regional and national competitiveness;[147]
- Technology transfer is not seen as a high-enough level priority for National Laboratories or DOE Programs;[148] and
- Smaller firms find it hard to work with DOE.[149]

Underlying many of these studies is the implicit understanding that innovation in energy is fundamentally different from innovation in many other sectors of the economy. Clean energy companies face high up-front capital requirements and highly regulated markets. While this is also true for the pharmaceutical sector, the margins on commercialized products are much tighter and the ability to design a competitive technology much lower, potentially impacting the appetite of investors for the risks. For clean energy start-ups, the lack of resources is a particular challenge

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142 The National Academy of Public Administration, Positioning DOE's Labs for the Future.
143 Secretary of Energy Task Force, Report of the SEAB Task Force on DOE National Laboratories. https://www.energy.gov/sites/prod/files/2015/06/f23/SEAB%20Lab%20Task%20Force%20Interim%20Report%20Final_0.pdf
144 American Energy Innovation Council and Bipartisan Policy Center, *U.S. Energy R&D Architecture*. https://bipartisanpolicy.org/wp-content/uploads/2019/03/BPC-AEIC-Energy-RD-Architecture.pdf
145 Information Technology & Innovation Foundation, *Clean Energy Start-Up Companies*. https://itif.org/publications/2020/08/24/clean-energy-start-companies-are-most-likely-succeed-when-they-partner
146 *Ibid*.
147 United States Department of Energy, *Final Report – Commission to Review the Effectiveness of the National Energy Laboratories*. https://www.energy.gov/labcommission/downloads/final-report-commission-review-effectiveness-national-energy-laboratories
148 Secretary of Energy Task Force, Report of the SEAB Task Force on DOE National Laboratories. https://www.energy.gov/sites/prod/files/2015/06/f23/SEAB%20Lab%20Task%20Force%20Interim%20Report%20Final_0.pdf; *Ibid*.
149 Secretary of Energy Task Force, Report of the SEAB Task Force on DOE National Laboratories. https://www.energy.gov/sites/prod/files/2015/06/f23/SEAB%20Lab%20Task%20Force%20Interim%20Report%20Final_0.pdf

because the venture capital model, which is "built around short-term, quick returns, was designed primarily for information technology (IT) companies... and 'patient' investors... are scattered."[150]

Many of the recommendations proposed in these reports have been implemented by DOE. For example, creation of the ACT mechanism and its use of SPPs, full implementation of the TCF and expansion of the OTT's role, gathering comprehensive and "reliable performance data," preparing the Technology Transfer Execution Plan, and developing a clearinghouse of DOE technologies – the Lab Partnering Service.[151] Other recommendations necessary for an optimized and robust technology transfer program require Congressional action or high-level DOE leadership in such areas as entrepreneurial leave policy, dedicated resources for technology transfer activities, clarification of legislative language regarding software copyright, U.S. manufacturing, conflicts of interest, CRADAs, March-In Rights, and creation of a national DOE foundation, as is the topic of this report.[152]

### *3.6.1 Proposed Legislation Addressing DOE Technology Transfer*

Recent legislative proposals have proposed to authorize the Small Business Voucher program, name the OTT Coordinator as the Chief Commercialization Officer reporting directly to the Secretary, and extend to NETL special hiring authority and the ability to fund a Directed Research and Development (DR&D) program, akin to the LDRD program at the government-owned, contractor-operated (GOCO) Labs.[153]

According to Congressional staff, interest in a foundation that could raise private funding to support DOE tech transfer programs was stimulated in part by the perceived success of other Foundations (Foundation for the National Institutes of Health (FNIH), Foundation for Food and Agriculture Research (FFAR)) in supporting the missions of their agencies, as well as the more specific interest in taking DOE tech commercialization efforts to a higher level. Congressional interest in establishing a DOE national Foundation has been led by Senator Chris Coons (D-DE) and Representative Ben Ray Lujan (D-3/NM). The Impact for Energy Act, introduced by Senator Chris Coons (D-DE) and Senator Lindsey Graham (R-SC) on June 27, 2019, proposes to establish a DOE foundation to channel private sector investment that address challenges. On March 2, 2020, the Impact for Energy Act was offered as an amendment to the American Energy Innovation Act (AEIA), which had been introduced on February 22, 2020 by Senator Lisa Murkowski (R-AK) and Senator Joe Manchin III (D-WV), Chair and Ranking Member respectively of the Senate Energy and Natural Resources Committee. The Study Team learned that as of December 2020, the AEIA without the Coons/Graham amendment is pending action by pre-conference discussions by House and Senate staff.

In the House, a substantially expanded version of the Impact for Energy Act was included in the Energizing Technology Transfer Act, approved by the House Science, Space and Technology Committee on September 14, 2020, which was included in the Clean Economy Jobs and

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[150] *Ibid.*
[151] United States General Accounting Office, *Technology Transfer: Clearer Priorities and Greater use of Innovative Approaches Could Increase the Effectiveness of Technology Transfer at Department of Energy Laboratories.*
[152] Information Technology and Innovation Foundation, *Mind the Gap.* https://itif.org/publications/2020/05/11/mind-gap-design-new-energy-technology-commercialization-foundation
[153] 116th Congress, United States House of Representatives, H.R.3607 "Fossil Energy Research and Development Act of 2019". https://www.congress.gov/bill/116th-congress/house-bill/3607/text

Innovation Act, passed by the full House on September 24, 2020. The Act sets forth the following clear statement of the importance of technology transfer: *Section 2 "(5) the Department of Energy must show significant leadership in enabling the transfer of new technologies to the private sector, particularly through the Office of Technology Transitions."* The pending legislation, if enacted as written, would amend or authorize a number of existing and new programs including a Clean Energy Innovation Partnership Program, a National Clean Energy Incubator program, a Clean Energy Technology University Prize Competition, the Lab Partnering Service Pilot Program, the Lab Embedded Entrepreneurship Program, the Small Business Voucher Program, and the Technology Commercialization Fund, and specifies criteria for the Entrepreneurial Leave Program and for Outside Employment Activities. It would also delegate signature authority to Lab Directors for agreements under $1 million, authorize funding for the OTT, and direct the appointment of full-time equivalents (FTEs) to support certain programs.

The bill would add a new category in the Regional Clean Energy Innovation Partnerships for Frontline Communities. The term 'frontline community' is defined as "a community with significant representation of communities of color, low-income communities, or Tribal or indigenous communities that experiences, or is at risk of experiencing, higher or more adverse human health or environmental effects." This definition would clarify who is included in a key purpose of the program, to "support the expansion of clean energy tools and technologies to low-income and frontline communities," and is consistent with the General provision to "support regional clean energy innovation partnerships that… improve economic development outcomes in economically distressed areas."

In parallel, Congressional legislation amending Stevenson-Wydler has been proposed, which has the effect of addressing several of the issues identified in external studies and internal analysis, including authority related to agency foundations. This legislation was the result of a work element of the President's Management Agenda Lab-to-Market CAP Goals for Technology Transfer, and the preparation of NIST Special Publication 1234, "Return on Investment Initiative for Unleashing American Innovation."[154]

The report found that "While the Bayh-Dole Act and Stevenson-Wydler Act provide essential authorities that facilitate the transfer and translation of federally funded R&D to innovate products, processes and services for the American people, there are numerous provisions that stakeholders indicated would benefit from clarification."[155]

DOE organizations provided detailed comments to NIST, which identified barriers to technology transfer:

- DOE National Laboratory Technology Transfer Working Group (TTWG): TTWG provided "comments on issues that have created barriers in the effective transfer of technology, knowledge, and capabilities resulting from federal R&D." Proposed solutions included the authority for GOGOs to copyright software and retain resulting royalties; the need to provide maturation funding across all scientific disciplines and Labs; the delegation of

[154] National Institute of Standards and Technology, *Return on Investment Initiative, Final Green Paper*. https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1234.pdf
[155] National Institute of Standards and Technology, *Return on Investment Initiative, Final Green Paper,* 105, 23. https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1234.pdf

decisions to the lab level for CRADA agreements and SPPs; adequate funding for ORTA functions at the laboratory; more flexibility to work with foreign-owned companies; and creation of a formal entrepreneurial leave program.[156]

- DOE National Laboratory Directors' Council: The NLDC supported many of the ideas the TTWG had offered and emphasized key focal areas, including uniform policy on software copyright ownership, clarification of the "substantial manufacture in the U.S." provision, flexibility in industry cost-share requirements, clearer guidelines for managing conflicts of interest, a streamlined review process for CRADAs, and clarification of the "march-in rights" clause.[157]
- Sandia National Laboratories stated that the lab supports "efforts to maximize the impact of federally funded innovations" and described systemic challenges to the effective transfer of technology:
    - Steep overhead charges;
    - Limitation on rights to software written under a CRADA;
    - Protection of trade secrets;
    - Limited ability to support start-ups;
    - Unclear guidance on applying conflict of interest (COI) requirements; and
    - Inconsistent requirements for measurement of tech transfer.
- Lawrence Berkeley National Laboratory recommended that technology transfer and intellectual property (IP) licensing be considered a core mission for the technology development approach of national labs and an integral part of scientific project management and program development. Metrics that measure the impact of technology transfer activities should be clearly defined, and a distinct technology transfer workflow that is transparent, consistent, and predictable should be created and communicated.

In HR 5685, the "Securing American Leadership in Science and Technology Act of 2020 (SALSTA)" introduced on January 28, 2020, proposes a series of amendments to Stevenson-Wydler, addressing such items as software copyright protection, protection of trade secrets, other transaction authority, reporting and metrics, and expanding DOE's proven ACT authority to all federal agency GOCOs. Section 809 grants to "A Government-owned Federal laboratory" the authority to "establish or enter into an agreement with a nonprofit organization to establish a Federal laboratory in support of its mission."

These recent legislative proposals proposed to authorize various new functions to elevate ongoing technology transfer activities. The congressional interest in a foundation that could raise private

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[156] These proposed solutions apply to both GOGOs and GOCOs.
[157] March-in rights refer to how "The Federal Government reserves the right to ensure that a contractor, or assignee, or exclusive licensee of intellectual property developed with Federal funding is taking effective steps to further develop the invention so that it is available to the public." From: United States Code, Title 35, Section 203 *"March-in rights"*. https://www.law.cornell.edu/uscode/text/35/203; In 2018, OTT coordinated with the TTWG to develop a CRADA alternate clause library to streamline negotiations for non-standard agreement. From communication with DOE on November 27th, 2020.

funding to support DOE tech transfer programs was stimulated in part by the perceived success of other foundations. The previous section shows the various working groups and organizations in supporting the missions of their agencies, as well as the more specific interest in taking DOE tech commercialization efforts to a higher level.

## 3.7 Conclusion

This chapter presented a high-level overview of DOE's current technology transfer activities, the legislative framework that governs this activity, the numerous studies and reports that have offered recommendations for improvements, DOE's initiatives and pilot programs that have advanced the agency's goals, and proposed legislation that would support enhanced levels of activity, including the establishment of a DOE foundation.

The chapter further identified significant areas that should be considered as part of DOE's portfolio, such as its extramural programs, and new challenges facing the nation that the agency could address, such as providing clean energy tools and technologies to low-income and frontline communities. The analysis observed that DOE's network of 17 National Laboratories are the drivers of the agency's technology transfer activity and will continue to play the central role in any expanded efforts. Accordingly, the following chapter examines the operations and interactions of these organizations.

# Chapter 4: Enhancing Tech Transfer at the DOE Laboratories

The DOE National Laboratories support the agency's missions in science and energy research, nuclear security, and environmental stewardship of the nuclear weapons complex. As DOE states, "from basic research and scientific discovery to development and demonstration of advanced technologies and other innovations, the seventeen world-class institutions constitute the most comprehensive research and development network of its kind."[158] Each lab addresses its mission through a unique collection of scientific tools, facilities, capabilities, and projects.

This chapter explores the changing contexts for the technology transfer mission with a focus on the National Laboratories. Established to realize strategic objectives associated with the Cold War, the labs took on an added mission in the 1980s to boost the nation's competitiveness by bringing more ideas from the lab to the marketplace. Today, once again, the labs are being challenged to adapt to new realities. To address this challenge, the labs are expanding the idea of technology transfer—going beyond the traditional parameters of promoting patents, licenses, cooperative agreements, and entrepreneurial start-ups—to now include a larger network of cooperative relationships with universities and community colleges, large and small businesses, manufacturing facilities, banks and venture capital investors, philanthropies, and state and federal programs.

The task of exploring the potential for foundations to help build out a twenty-first century innovation ecosystem, where the National Laboratories can serve as dynamic points of connection, starts with understanding the operational context of the labs. In this regard, this chapter surveys the diversity of the seventeen labs in terms of their missions, activities, location, and scale. It also examines the linkages between broad public policy goals for technology transfer and ecosystem development and the micro-incentives facing lab scientists and administrators. The final section of this chapter samples the growing set of instruments through which DOE labs have forged connections with external actors. These networks can support the mission of each of the labs by fostering the regional talent and skill base, creating a vibrant supplier network, and encouraging greater public support for its work.

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[158] Department of Energy, Annual Report on the State of the DOE National Laboratories, January 2017.
Adam Cohen, Kevin Doran, and David M. Catarious, "Annual Report on the State of the DOE National Laboratories" (Department of Energy, January 2017), https://www.energy.gov/downloads/annual-report-state-doe-national-laboratories.

**Box 4.1: What is an Innovation Ecosystem?**

An innovation ecosystem refers to an evolving network of interconnections among a variety of participants in an innovation economy. This includes individual entrepreneurs, as well as corporate actors such as small and large businesses, financial organizations, national and regional governments, universities, and National Laboratories. Further, the idea of an ecosystem highlights the importance of norms, rules, and institutions—whether existing or prospective—in acting as connection points across this arena. They work by shaping the incentives that these actors face in resolving the challenges inherent in cooperating with each other.[159]

Foundations, in this regard, can encourage the growth of innovation ecosystems by creating a forum or other shared point of reference that solves specific challenges that actors in an innovation economy face in working together. By enhancing the connectivity across an innovation economy, well-designed foundations can complement other means to foster a vibrant innovation ecosystem.

## 4.1 The Changing Context of Technology Transfer

Although founded to address the Cold War rivalry with the Soviet Union by conducting fundamental scientific research and by building and maintaining the nation's nuclear arsenal, DOE and its labs were utilized through the subsequent decades to respond to a series of emerging national challenges. The Department responded to the oil crisis and competitiveness challenges of the 1970s and 1980s by creating new structures to conduct applied research in renewable energy and by implementing programs to encourage cooperative research with businesses. Today, the labs and many federal agencies are being called upon to respond to a new strategic environment where research, innovation, and manufacturing are highly globalized; where the bilateral US-China relationship is characterized by a disruptive technological and geo-political rivalry; and where the nation's own manufacturing and innovation networks are under stress in many places.[160]

The National Laboratories primarily grew out of Manhattan Project facilities created to serve the imperatives of the Cold War nuclear arms race. Lawrence Livermore and Los Alamos National Laboratories played a primary role in nuclear weapons design, development, and testing, and Sandia Laboratories are on the site of an earlier weapons assembly and training facility. Complementing this effort, the Pacific Northwest National Laboratory, located where the Hanford Site led in the production of plutonium, and Oak Ridge National Laboratory played a primary role in the production of enriched uranium for the weapons complex. Oak Ridge also led the development of gaseous diffusion plants, lithium fuel development, and genetics and biological radiation research.

The Idaho National Laboratory played a primary role in the research and development, design, construction, and testing of prototype nuclear reactors for both civilian and defense applications. In turn, Argonne National Laboratory led the development of reactors for use in nuclear submarines and was also instrumental in the development of the civil nuclear power industry.

[159] Sujai Shivakumar, "Beyond Clusters: Crafting Contexts for Innovation," *The Review of Austrian Economics*, April 2020.
[160] "SEAB Innovation Working Group: Initial Findings" (Department of Energy: Secretary of Energy Advisory Board, May 20, 2020. Access at https://www.energy.gov/sites/prod/files/2020/05/f74/SEAB_Inno_Preliminary%20Findings%20%28Final%29.pdf.

Brookhaven National Laboratory also played an indirect role in the Cold War with promotion of peaceful uses of the atom and technologies to advance nuclear non-proliferation.[161] As the agency responsible for Stockpile Stewardship, the design, development, and testing of nuclear weapons, DOE continues to play a central role in their research and development.[162]

In addition to research on the development and implementation of nuclear technologies, the labs conduct basic scientific research and are the nation's largest supporter of basic research in the physical sciences. This includes physics, chemistry, computer science, applied mathematics, materials science, nanoscience, and engineering, as well as systems biology and environmental sciences. Increasingly, the labs also have a responsibility for cybersecurity in the energy sector and in the protection of nuclear technologies. Collectively, the 17 DOE labs have produced path breaking research, as validated by some 115 Nobel Prizes awarded to scientists either working at or affiliated with these labs.[163]

These exceptional research, development, and deployment efforts of DOE played a pivotal role for the United States during the Cold War. At the same time, the highly classified nature of much of this research requires secrecy, and the decisions made long ago to locate some of these labs in remote areas have also reinforced a culture of seclusion. This portion of the legacy of DOE research and development that must remain classified or sensitive runs counter to the new strategic realities where all federal agencies are being called on to emphasize regional connectivity and external engagement to more market commercialization and global competitiveness.

The National Laboratories continued to evolve and adapt during the oil crisis when the Solar Energy Research Institute—since designated the National Renewable Energy Research Laboratory (NREL)—was established in 1977. This period also saw the DOE Organization Act of 1977, which created the Department of Energy to bring together "the defense responsibilities that included the design, construction, and testing of nuclear weapons dating from the Manhattan Project effort to build the atomic bomb; and a loosely knit amalgamation of energy-related programs scattered throughout the federal government."[164]

In addition, the Federal Labs, including the National Laboratories, were obliged in the 1980s to take on an explicit technology transfer mission to address the perceived competitiveness challenge from Japan. As described in Chapter 3 and Appendix I: Additional Information Regarding Technology Transfer, Congressional Interest, Congress directed the labs to develop mechanisms to advance the transfer of technologies developed at the labs to the marketplace through a series of legislation passed in the 1980s. This set of legislation includes the Small Business Innovation Development Act of 1982 (which established the Small Business Innovation Research Program (SBIR)) and the Stevenson-Wydler Act of 1980, which, among other provisions, obliges each DOE

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[161] Amy F Woolf and James D Werner, "The U.S. Nuclear Weapons Complex: Overview of Department of Energy Sites," *Congressional Research Service*, February 3, 2020, 37.
[162] Amitai Y Bin-Nun et al., "The Department of Energy National Laboratories," *Harvard Kennedy School: Belfer Center for Science and International Affairs*, November 2017, 112.
[163] "DOE Nobel Laureates | U.S. DOE Office of Science (SC)," Government, Office of Science, November 12, 2019, https://science.osti.gov/About/Honors-and-Awards/DOE-Nobel-Laureates.
[164] Department of Energy, "A Brief History of the Department of Energy," Government, DOE Office of Legacy Management, accessed November 9, 2020, https://www.energy.gov/lm/doe-history/brief-history-department-energy.

lab to establish a technology transfer office.[165] Congress also required additional technology transfer focus by DOE through the Energy Policy Act of 2005, Sec 1001, which established the Technology Transfer Coordinator and the Energy Technology Commercialization Fund, among other enumerated activities for oversight.

Congress again expressed interest in promoting technology transfer from DOE labs again in the COMPETES Act of 2007, which established ARPA-E. ARPA-E is tasked broadly with tackling the nation's energy challenges in a way that could translate basic research into technological breakthroughs while also addressing economic, environmental, and security issues.[166]

Many of these technology transfer programs have been subject to evaluation. For example, a recent assessment of SBIR by the National Academy of Sciences, Engineering, and Medicine (NASEM) found DOE's SBIR program to be broadly effective. The NASEM report also observed that many labs still regard technology transfer program funding—derived from a small percentage set-aside from DOE's extramural research budget—to be much like a "tax." It also observed that small businesses often find the labs to be "bureaucratic" and "unsympathetic" to their needs even though the labs' crowdsourcing of SBIR research responds directly to solicitations prepared by DOE program managers who, in turn, solicit inputs from numerous stakeholders, including the National Laboratories.[167]

Despite these policy and program initiatives, there remain important areas of unfulfilled potential in technology transfer activity. Much of this challenge focused on the issue of technology scale-up, where the surrounding innovation ecosystem needs to be further developed. In this regard, a report issued by the Information Technology and Innovation Foundation (ITIF), the Center for American Progress, and the Heritage Foundation – a trifecta of policy research organizations spanning the political spectrum - argues that the labs "have not kept pace" with a rapidly changing innovation environment, and that their "tether to the market is weak."[168]

Recent analyses of the process of innovation through an ecosystem or engineering systems approach show that activities that create multiple intersecting and layered networks of cooperation can help revive and grow the nation's innovation and manufacturing ecosystems.[169] Relatedly, there is a growing concern that the development and manufacturing of innovative technologies within the United States is too often arrested by an inadequate technical and financial infrastructure—sometimes referred to as the "missing middle"—needed to provide broad and systematic support for translational innovation by (particularly) small companies.[170]

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[165] Stevenson-Wydler Technology Innovation Act, Pub. L. No. 96-480, as amended by the Federal Technology Transfer Act of 1986 (Pub. L. No. 99-502), the Omnibus Trade and Competitiveness Act (P.L. 101-418), the National Competitiveness Technology Transfer Act of 1989 (Pub. L. No. 101-189), the National Defense Authorization Act for FY91 (Pub. L. No. 101-510), the Technology Transfer Improvements and Advancement Act (Pub. L. No. 104- 113), and the Technology Transfer Commercialization Act (Pub. L. No. 106-404).

[166] National Academy of Sciences, Engineering and Medicine, *An Assessment of ARPA-E* (Washington, DC: The National Academies Press, 2017), https://doi.org/10.17226/24778.

[167] National Academies of Sciences, Engineering and Medicine, *SBIR/STTR at the Department of Energy* (Washington, DC: The National Academies Press, 2016), https://doi.org/10.17226/23406.

[168] Matthew Stepp et al., "Turning the Page: Reimagining the National Laboratories in the 21st Century Innovation Economy" (Information Technology & Innovation Foundation, June 19, 2013), http://www2.itif.org/2013-turning-the-page.pdf.

[169] Ove Granstrand and Marcus Holgersson, "Innovation Ecosystems: A Conceptual Review and a New Definition," *Technovation* 90–91 (February 2020): 102098, https://doi.org/10.1016/j.technovation.2019.102098.

[170] National Research Council, *The Flexible Electronics Opportunity* (Washington, DC: The National Academies Press, 2014), https://doi.org/10.17226/18812.

The case of iBeam, a commercial startup, which was spun-off from Los Alamos National Laboratory and which established its operations in Santa Fe, New Mexico in late 2011, is illustrative of the challenge outlined above. With support from DOE SBIR and ARPA-E awards, iBeam was able to advance a potentially disruptive flexible lighting technology that fabricates LEDs directly on metal foil before it hit the "missing middle" in the U.S. innovation ecosystem. iBeam was then obliged to secure follow-on funding from Samsung Ventures to grow the company, placing it now within the ecosystem of the Korean display industry.[171]

U.S. competitors sustain this middle space in their innovation and manufacturing systems in different ways. Corporate conglomerates in Japan and Korea and large state-owned enterprises in China address the technology scale-up challenge within their extensive networks. In Germany, the Fraunhofer institutes and research centers—which receive extensive public funding—serve to bridge the space between the research base and industry. Small companies can access sophisticated computer design and simulation tools and platforms, prototyping facilities, precision measuring and test equipment, and consult a deep bench of expertise.[172] In many cases, equipment makers can also test their machines on pilot lines in a factory environment. This mezzanine infrastructure for scale-up is often missing in the United States.

In the United States, Manufacturing USA, a national network for manufacturing innovation, has been developed over the past decade to help revive parts of the "missing middle."[173] The DOE labs can also assist in this task by sharing their expertise and equipment, and by establishing cooperative links with other actors within their regional economies and beyond.

These dual roles in technology transfer—technology push and ecosystem building—come into focus as the Department of Energy and its National Laboratories strive to adapt to new global strategic challenges. As the Secretary of Energy Advisory Board (SEAB) Innovation Working Group points out in its 2020 report, the United States' lead in innovation is under threat and, with it, the nation's security and commercial prosperity. SEAB notes that "as steward of the great scientific capabilities embodied in the National Laboratory complex, the U.S. Department of Energy must continuously improve efficiency and production across the mission areas of energy, science and nuclear security. Today there is only one way to retain leadership while still respecting human rights, the environment, international partnerships, and hard-earned property rights: INNOVATION. The U.S. government, our industrial base and our academic institutions must innovate in new and faster ways."[174]

To consider the role that a foundation can play to address the "missing middle," this chapter looks next at the diversity of scale and mission and the operational incentives for technology transfer found across DOE National Laboratories.

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[171] IBeam Materials receives follow-on funding from Samsung Ventures, July 27, 2020. Ibeammaterials.com
"Follow-on Funding," iBeam Materials, accessed November 9, 2020, http://www.ibeammaterials.com/followonfunding.

[172] Rising to the Challenge: U.S. Innovation Policy for the Global Economy (Washington, D.C.: National Academies Press, 2012), https://doi.org/10.17226/13386.

[173] National Academies of Sciences, Engineering, and Medicine, *Securing Advanced Manufacturing in the United States: The Role of Manufacturing USA: Proceedings of a Workshop* (Washington, DC: The National Academies Press, 2017), https://doi.org/10.17226/24875. *Rising to the Challenge, U.S Innovation Policy for the Global Economy*

[174] SEAB Innovation Working Group Initial Findings, United States Department of Energy, 2020.

## 4.2 The Operational Diversity of DOE National Laboratories

The seventeen DOE labs are a diverse set, varying by scale and location, by mission and type of contractor, by sources of funding, and by the mix of basic, applied and national security-related research that they conduct. The labs conduct research, development, and demonstration activities across multiple primary mission areas to serve specific national needs. Table 4.1 lists each of the labs along with their year of establishment, location, management and operating organizations, sponsoring DOE program office, type of contractor, and recent budget appropriations from Congress. Foundations that are focused on particular labs can better adapt to their distinctive characteristics, organization, mission, and location.

**Figure 4.1: Diversity of DOE National Laboratories**

| Est. | Name | Location | Operated by | Branch | M&O Contract | 2020 Budget ($k) |
|---|---|---|---|---|---|---|
| 1947 | Ames Laboratory | Ames, Iowa | Iowa State University (since 1947) | Office of Science | GOCO | $47,024 |
| 1946 | Argonne National Laboratory | DuPage County, Illinois | UChicago Argonne, LLC | Office of Science | GOCO | $867,162 |
| 1947 | Brookhaven National Laboratory | Upton, New York | Stony Brook University (since 1998) | Office of Science | GOCO | 575,792 |
| 1967 | Fermi National Accelerator Laboratory | Batavia, Illinois | Fermi Research Alliance (since 2007) | Office of Science | GOCO | $584,493 |
| 1949 | Idaho National Laboratory | Idaho Falls, Idaho | Battelle Energy Alliance | Office of Nuclear Energy | GOCO | $1,560,000 |
| 1931 | Lawrence Berkeley National Laboratory | Berkeley, California | University of California (since 1931) | Office of Science | GOCO | $888,572 |

| Est. | Name | Location | Operated by | Branch | M&O Contract | 2020 Budget ($k) |
|---|---|---|---|---|---|---|
| 1952 | Lawrence Livermore National Laboratory | Livermore, California | Lawrence Livermore National Security, LLC (since 2007) | National Nuclear Security Administration | GOCO | $1,887,839 |
| 1943 | Los Alamos National Laboratory | Los Alamos, New Mexico | Triad National Security, LLC (Since 2018) | National Nuclear Security Administration | GOCO | $2,578,527 |
| 1910 | National Energy Technology Laboratory | Pittsburgh, Pennsylvania | Department of Energy | Office of Fossil Energy | GOGO | $712,848 |
| 1977 | National Renewable Energy Laboratory | Golden, Colorado | MRI Global (1997–2008) Alliance for Sustainable Energy, LLC (since 2008) | Office of Energy Efficiency and Renewable Energy | GOCO | $464,275 |
| 1943 | Oak Ridge National Laboratory | Oak Ridge, Tennessee | UT–Battelle (since April 2000) | Office of Science | GOCO | $2,058,670 |
| 1965 | Pacific Northwest National Laboratory | Richland, Washington | Battelle Memorial Institute (since 1965) | Office of Science | GOCO | $599,239 |
| 1951 | Princeton Plasma Physics Laboratory | Princeton, New Jersey | Princeton University (since 1951) | Office of Science | GOCO | $100,053 |
| 1948 | Sandia National Laboratories | Albuquerque, New Mexico | Honeywell International (since 2017) [4] | National Nuclear Security Administration | GOCO | $2,518,989 |

| Est. | Name | Location | Operated by | Branch | M&O Contract | 2020 Budget ($k) |
|---|---|---|---|---|---|---|
| 1952 | Savannah River National Laboratory | Aiken, South Carolina | Savannah River Nuclear Solutions, LLC (since 2008) | Office of Environmental Management | GOCO | $3,088 |
| 1962 | SLAC National Accelerator Laboratory | Menlo Park, California | Stanford University (since 1962) | Office of Science | GOCO | $404,105 |
| 1984 | Thomas Jefferson National Accelerator Facility | Newport News, Virginia | Jefferson Science Associates, LLC (since 2006) | Office of Science | GOCO | $139,466 |

(Figure 4.1 Diversity of DOE National Laboratories created by National Academy of Public Administration from publicly available information from DOE. "GOGO" Government Owned, Government Operated lab. "GOCO" Government Owned, Contractor Operated lab.) [175]

### *4.2.1 Diversity of Activities*

The labs feature a high degree of variation across their features as well as their scope of activities. Cataloged by the 2017 Annual Report on the State of the Laboratories[176], the labs undertake a wide range of activities that are designed to:

1. Advance U.S. energy security and leadership in clean energy technologies to ensure the ready availability of clean, secure, reliable, and affordable energy;
2. Deliver discovery and innovation in physical, chemical, biological, engineering, and computational and information sciences that advance our understanding of the world around us;
3. Enhance global, national, and homeland security by ensuring the safety and reliability of the U.S. nuclear deterrent, helping to prevent the proliferation of weapons of mass destruction, and helping to secure nuclear materials around the world;
4. Develop deployable technologies for the safe cleanup of the DOE Nuclear Complex following five decades of nuclear weapons development, production, and testing;

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[175] "Department of Energy FY 2020 Congressional Budget Request: Laboratory Tables Preliminary." Department of Energy: Office of Chief Financial Officer, March 2019. https://www.energy.gov/sites/prod/files/2019/03/f60/doe-fy2020-laboratory-table.pdf. Kusnezov, Dimitri. "The Department of Energy's National Laboratory Complex." PowerPoint Presentation presented at the Commission to Review the Effectiveness of National Energy Laboratories, July 18, 2014.
[176] Cohen, Doran, and Catarious, "Annual Report on the State of the DOE National Laboratories."

5. Design, build, and operate cutting-edge scientific instrumentation and facilities—often of a scale impractical for universities—and make these resources available to the national research community;
6. Serve the national interest not only as leaders in science and technology, but also as rapidly deployable national assets in times of national need;
7. Move innovation to the marketplace and strengthen U.S. competitiveness; and
8. Train the next generation of scientists and engineers, particularly in DOE core mission areas.

### *4.2.2 Diversity of Location*

**Figure 4.2: Geographic Map of DOE National Laboratories**


(Source: The U.S Department of Energy)

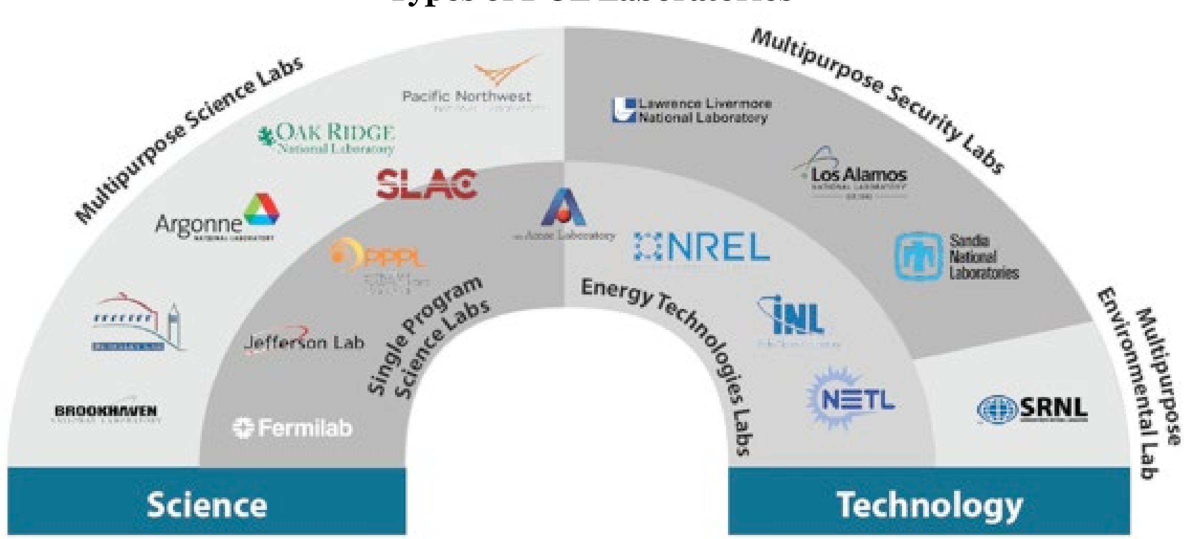
The labs are also geographically dispersed. As represented in figure 4.2, the labs are distributed across fourteen states. While some labs are located in regions that have strong innovation economies (notably SLAC and Lawrence Berkeley Lab in California's Bay Area, and Fermilab and Argonne National Lab near Chicago), other labs, especially those that conduct sensitive research and development connected with nuclear weapons are located in more remote regions. Sandia and Los Alamos National Laboratories, located in New Mexico, trace their origins to the Manhattan Project. The Idaho National Laboratory's 890-square-mile complex is found in the relative isolation of the high desert of eastern Idaho. And the Pacific Northwest National Laboratory is located in rural eastern Washington state. [177]

These regional differences affect the strategy that each lab employs to address its mission to move ideas out of the lab and into the market and to grow supportive ecosystems. Labs located in innovation-rich regions may still face hurdles in establishing trust required for cooperative relationships with other regional actors. The labs in more remote areas may not as easily find a viable population of commercial partners in their vicinity who can license technologies, sign research and development agreements, and launch start-ups. Several of these regions also have no major universities collocated near the labs. Indeed, these labs may need to invest in their regional innovation ecosystem for their own needs through programs that, for example, develop a local skilled technical workforce. Some labs may also have to cast their nets over a wider geographical area in order to capture and knit the needed scientific, human, capital, and commercial assets into a viable innovation ecosystem. Of course, some types of lab activities are becoming more virtual, a trend that is likely to continue (although still problematic given the security issues surrounding a number of the labs).

### *4.2.3 Diversity of Labs and their Stewardship*

**Figure 4.3: Types of DOE Laboratories**

**Types of DOE Laboratories**




(Source: The U.S. Department of Energy)

The seventeen DOE labs vary in size and the nature and complexity of their mission. Ten of the labs are sponsored by DOE's basic research wing, the Office of Science. They include smaller

[177] PNNL has opened a small satellite site in Seattle to take advantage of the innovation ecosystem in that region.

single-purpose labs such as the Princeton Plasma Physics Laboratory in New Jersey and larger multipurpose labs such as Oak Ridge National Laboratory in Tennessee.

DOE's National Nuclear Security Agency (NNSA) sponsors three of the labs—Los Alamos National Laboratory in New Mexico, Lawrence Livermore National Laboratory in California, and Sandia National Laboratory in New Mexico. The multipurpose security labs conduct nuclear weapons research. The four others, including the National Renewable Energy Laboratory in Colorado, are sponsored by DOE's applied research programs.

The energy technology labs, which conduct closer-to-market applied research, are more favorably placed to engage in traditional forms of technology transfer. On the other side, labs engaged in nuclear weapons research within high security facilities face challenges with bringing outside collaborators to their site (although some have found creative ways to cooperate with partners outside the security fence). Also, labs that conduct fundamental research are more removed from the application and commercialization stages of the innovation process. This latter set of labs may benefit from a broader, more innovation-focused interpretation of technology transfer where the lab's portfolio of activities can indirectly support regional economies as well as help uphold the operations of the lab. To be effective, lab associated foundations need to complement the missions of each lab and their distinctive potential to support technology transfer and ecosystem development in different ways.

Accordingly, the expressed interest in technology transfer—and the potential role of a foundation—by the three sets of labs differs from each other. NREL, an energy technology lab, is actively considering the establishment of a lab associated foundation to facilitate its particular technology commercialization goals. The Office of Science has recently engaged in developing a strategic plan for the "Labs of the Future." This effort seeks to rethink the role of the science labs and identify new ways by which they can cooperate with industry and academia using new partnership models and funding mechanisms.

### *4.2.4 Diversity of Contractors*

DOE manages the 16 labs that are federally funded research and development centers through M&O contracts with industrial, academic, or nonprofit institutions. This set of contractors includes the University of California, the University of Chicago, and the Battelle Memorial Institute. Figure 4.1 provides the full list. The M&O model is designed to enable the labs and DOE to collaborate, with the goal of ensuring that the system remains agile in addressing changing national needs (given that the operational interests of DOE and the Lab operators can vary.)

Under the government-owned, contractor-operated (GOCO) model, DOE is responsible for establishing strategic and program direction, while the labs apply their expertise to determine precisely how to meet technical and scientific challenges and carry out programs, all in the public interest. The outlier, the National Energy Technology Laboratory (NETL), is government-owned and government-operated (GOGO), similar to research, development, and deployment (RD&D) labs in other Federal Government agencies. In the GOGO model, DOE establishes the strategic and program direction and conducts research and development activities in support of its applied energy mission.[178] As a DOE GOGO, NETL does not have the flexibility of a GOCO to establish a lab-associated foundation, absent authority from Congress.

**Box 4.2: National Energy Technology Laboratory (NETL)**

Established in 1910, NETL is the oldest of the National Laboratories, and arose out of the historic coal and oil mining industrial sector in the tri-State PA, WV, OH region. Formally designated as a DOE-National Laboratory in 1999, NETL is focused on Fossil Energy and has three major sites: Pittsburgh, PA; Albany, OR, and Morgantown, WV.

NETL is the only National Laboratory that is Government Owned, Government Operated (GOGO), whose technology transfer legal authorities are governed primarily by the Stevenson-Wydler legislation, and whose federal employees operate under the same rules as those at NASA, NIST, and NIH. As a GOGO, NETL enjoys a more integrated relationship with DOE than do the GOCOs and can act on behalf of DOE in a more direct fashion.[179]

The Office of Fossil Energy (FE) is NETL's primary program sponsor; according to the most recent NSF data, in 2018 FE's budget totaled $663 million of which $623 million represented Applied Research. According to DOE's FY 2020 Congressional Budget Justification, FE's enacted R&D budget was $750 million; Congress enacted $321 million for NETL, $88 million for R&D. NETL utilizes standard technology transfer mechanisms such as CRADAs, and subject to legal interpretation, it has limited authority to utilize "other transaction authority" and "partnership intermediary agreements."

As federal employees, its staff can both serve as program managers for DOE programs, such as FE's SBIR Program, and programs funded by EERE, and can perform work for other Program Offices such as SC, NE, and OE. NETL's unique combination of intramural research capability, and extramural work, involving 600 partners in 900 projects in 50 states, presents a valuable aggregation of capabilities.

However, NETL lacks the flexibility provided by the GOCO model, such as the ability to set aside funds for "Lab Directed Research and Development," the ability to take equity in start-up companies, to enter in Agreements for the Commercialization of Technology, or the authority to establish a local lab-associated foundation. NETL senior management has recognized the importance of a more diverse set of tools. The Study Team was informed that in October 2018, NETL completed an internal "Entrepreneurship and Innovation Assessment" which explored how NETL could more effectively transfer intellectual property, increase and streamline laboratory-industry engagements, and strengthen core capabilities.

Congress has also evinced interest in providing more flexibility to NETL. HR 3607, the Fossil Energy and Research Development Act of 2019, "Section 14, National Energy Technology Laboratory Reform," proposed granting to NETL "special hiring authority" and authorization to

[178] Cohen, Adam, Kevin Doran, and David M. Catarious. "Annual Report on the State of the DOE National Laboratories." Department of Energy, January 2017. https://www.energy.gov/downloads/annual-report-state-doe-national-laboratories.
[179] In interviews, the Study Team heard that FE enjoys a "very tight collaborative working relationship," daily interactions, weekly updates among senior management.

devote between 2-4 percent for Directed Research and Development (DR&D), similar to the GOCO's LDRD.

HR 5685, the Securing American Leadership in Science and Technology Act of 2020 (SALSTA), introduced in the House on January 29, 2020, and based upon the recommendations of the NIST ROI Green Paper, proposes amendments to the Stevenson-Wydler Act, which provide, among other authorities, the ability of a "Government-owned Federal laboratory…to establish a Federal laboratory Foundation in support of its mission," thereby providing to NETL the same creative opportunities currently available to DOE's 16 other National Laboratories.

### *4.2.5 Diversity in Technology Transfer Potential*

While all seventeen labs play a critical role in promoting DOE's overall missions, they are a diverse set--in terms of function, management, and scale. They also vary in terms of their range of activities, with the scope of these activities are contingent on, among other factors, the type of research conducted by a specific lab.

Overall, the unique mix of features found in each of the seventeen labs underlines the limits of comparing the performance of each lab against those of others. It also cautions against exclusive reliance on a traditional set of metrics covering the production of patents, licenses, cooperative agreements, and start-ups to assess success in lab technology transfer. The diversity found among the labs also means that any formulation to improve technology transfer from the labs—including the idea of a foundation—must accommodate the particular technical capabilities, unique mission, and varied regional economic features associated with each lab.

## 4.3 Operational Alignments and Technology Transfer

The labs face a common challenge, a shared legislative mandate to transfer technology in terms of moving ideas from the lab into the market, and a common set of instruments in the technology transfer toolkit. From the congressional perspective, technology transfer legislation aligns public policy to the mission of all the National Laboratories.

The 1989 National Competitiveness Technology Act as prescribed in 48 CFR 970.2770-43 requires National Laboratory M&O contractors to conduct technology transfer activities to promote the U.S. industrial competitiveness. Sections 3131, 3132, 3133, and 3157 of Pub. L. 101-189 and as amended by Pub. L. 103-160, Sections 3134 and 3160 focus on technology transfer as part of the mission for DOE National Laboratories. The management and operating Contractor is approved to conduct activities including:

> "identifying and protecting Intellectual Property made, created or acquired at or by the Laboratory; negotiating licensing agreements and assignments for Intellectual Property made, created or acquired at or by the Laboratory that the Contractor controls or owns; bailments; negotiating all aspects of and entering into CRADAs; providing technical consulting and personnel exchanges; conducting science education activities and reimbursable Strategic Partnership Projects (SPP); providing information exchanges; and making available laboratory or weapon production user facilities. It is fully expected that the Contractor shall use all of the mechanisms available to it to accomplish this technology transfer mission, including, but not limited to, CRADAs, user facilities, SPP, science

education activities, consulting, personnel, assignments, and licensing in accordance with this clause."[180]

However, despite formal dedication to authorities, appropriated budgets and missions, this clear policy aim is often not fully relayed into action. At closer resolution, it is apparent that the framework linking policy, programs, and activities does not always create the incentives required for effective technology transfer. Survey and focus group interviews with the technology transfer leads at the seventeen DOE labs conducted for this report highlight situations where goals and practices are not fully aligned, limiting a more robust realization of DOE's potential to move ideas from the lab and into the market.

### *4.3.1 DOE Versus Lab Contractor Priorities*

One area where the relay baton of the technology transfer mission may sometimes be dropped lies between DOE and the labs. The process of how the contracts are competed and evaluated reinforces the independence of the labs to pursue their core missions, with lab managers not sufficiently incentivized in many cases to advance stated DOE goals in technology commercialization.

This tension is documented in the 2015 report by the Commission to Review the Effectiveness of the National Energy Laboratories (CRENEL). This report to Congress found that the National Laboratories—especially the weapons labs—maintain a high degree of independence from DOE. At the same time, DOE tries to keep fully informed about their technical and financial progress as well as safety and security issues. "As a result, the CRENEL report observed that DOE micromanages work at the laboratories with excessive milestones and budget limitations and other requirements about how work should be done."[181] According to Jared Cohon, the co-chair of the commission, the myriad requirements can cause contractors and lab managers to focus too much on compliance exercises: "The question becomes are you complying with the requirements as opposed to whether you're accomplishing your mission."[182]

The accountability of the contractors is further strained because the M&O contracts are only infrequently competed for and the pool of alternative contractors is very limited, effectively protecting incumbent contractors from genuine competition.[183] In addition, the labs, which are often major employers in their states, have strong support from Congress, and this further insulates them to some extent from any leverage sought by DOE.

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[180] https://www.law.cornell.edu/cfr/text/48/970.5227-3
"48 CFR § 970.5227-3 - Technology Transfer Mission.," LII / Legal Information Institute, accessed November 9, 2020, https://www.law.cornell.edu/cfr/text/48/970.5227-3.
[181] Lamar Alexander, TJ Glauthier, and Jared L. Cohon, "Energy & Water Development: Securing America's Future: Realizing the Potential of the DOE National Laboratories," § Energy and Water Development Subcommittee (2015), https://www.appropriations.senate.gov/hearings/energy-and-water-development-securing-americas-future-realizing-the-potential-of-the-doe-national-laboratories.
[182] Adrian Chao, "Give U.S. the labs freer rein, commission urges skeptical senators," *Science,* October 30, 2015
[183] GAO, DEPARTMENT OF ENERGY: Actions Needed to Strengthen Acquisition Planning for Management and Operating Contracts. GAO-16-529: Published: Aug 9, 2016. Publicly Released: Sep 8, 2016.

Recent reviews—including those by the CRENEL and the SEAB Task Force on the DOE National Laboratories—have also warned that the oversight relationship between DOE and the labs has grown increasingly transactional rather than strategically driven by mission objectives.[184]

DOE's assessment of contractor performance is based on the Performance Evaluation and Measurement Plan (PEMP). The PEMP describes system attributes including performance expectations, roles and responsibilities, and the process by which M&O contractor's scientific, technological, and managerial performance will be evaluated. It serves to inform DOE decisions regarding performance fees and on whether to extend or to compete M&O contracts when they expire. The contractor is required to implement a comprehensive Self-Assessment Program that addresses both the strengths and weaknesses of the contractor's performance across all elements of the Statement of Work as well as agreed-upon critical outcomes, performance objectives, and performance indicators.

The PEMP score is based on eight overall goals, with sub-goals associated with each goal. For the Office of Science labs, as an illustration, the commercialization and partnership efforts of each lab are directly graded in:

- Goal 6.5 – Demonstrate Effective Transfer of Knowledge and Technology and Commercialization of Intellectual Assets. Goal 6.5 carries 20 percent of the weight of overall Goal 6: Deliver efficient, effective, and responsive business systems and resources that enable the successful achievement of the laboratory mission(s).
- Goal 4.3 – Leadership of External Engagements and Partnerships. Goal 4.3 carries 10 percent of the weight of overall Goal 4: Provide sound and competent leadership and stewardship of the laboratory.

The weights allocated to technology transfer reveal that in most cases the PEMP only minimally incentivizes the labs to comply with DOE goals relating to technology transfer. In a 2013 review of the metrics and systems that DOE uses to evaluate the performance of the labs, the Academy found that "In all cases, the available award fee [relevant to technology transfer] is small relative to the total lab budget. Further, in practice … all labs get most of their award fee, and only a small portion appears to be really 'at risk'."[185] Of course, even a small portion of the budget may be significant for some types of activities, and a positive PEMP evaluation can have reputational benefits. In any event, DOE took a number of steps, including the creation of a dedicated Office of Technology Transitions (OTT), in an attempt to streamline the relationship between headquarters and the labs.

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[184] Alexander, Lamar, TJ Glauthier, and Jared L. Cohon. Energy & Water Development: Securing America's Future: Realizing the Potential of the DOE National Laboratories, § Energy and Water Development Subcommittee (2015). https://www.appropriations.senate.gov/hearings/energy-and-water-development-securing-americas-future-realizing-the-potential-of-the-doe-national-laboratories.

[185] Jonathan Breul et al., "Positioning Doe's Labs For The Future: A Review Of Doe's Management And Oversight Of The National Laboratories" (National Academy of Public Administration, January 2013), https://www.napawash.org/uploads/Academy_Studies/13_01_Department_of_Energy_Review_of_Departmental_Management_and_Oversight_of_the_National_Laboratories.pdf.

### *4.3.2 Misalignments within the Labs*

The Study Team survey and focus group discussions with the technology transfer leads at the seventeen National Laboratories, taken together, reveal a further misalignment between the broader set of technology transfer goals and the institutional incentives found within the labs. The Study Team's analysis illustrates the great variation among the labs in their views and approach to technology transfer, yielding a different complement of issues for each lab.

The first set of issues described to the Academy relate to the unique nature of research and development being carried out in DOE labs that may inhibit the effective movement of ideas from lab to market. Fundamental research conducted by many of the labs is, by nature, not sufficiently mature for immediate development through prototyping, demonstration, and commercialization, and therefore it is not ready to be licensed, patented, or commercialized within a start-up firm. Other DOE labs focus on sensitive national security missions; these labs may include classified research in their portfolio or be engaged in weapons development, where external partnerships and broad product commercialization is not desirable.

The second set of issues highlighted by the technology transfer leads at the labs concerns the administrative mechanisms that the labs use to fund their research. On average, lab funding is narrowly assigned to specific projects and not adaptable to offshoot research and market opportunities that might arise. In addition, they pointed out that DOE funding for research and development to activities typically extend up to technology readiness levels (TRL) 3 and 4. Given that opportunities for private investment only begin at TRL 6 and 7, this leaves a gap around TRL 5. These internal obstacles come on top of those posed by the "valley of death," as it is known, where ideas born in the lab fail to commercialize either because their value goes unrecognized as solutions to problems different from that for which they were developed or because the "problems" they might solve have not yet been clearly articulated.

The third set of issues described to the Academy relate to the disincentives facing the scientists and other staff who work at the labs to commercialize their research. The scientists at the National Laboratories were often narrowly specialized and difficult to replace; as a consequence, the technology transfer leads noted that lab managers try to make it easy for these scientists to stay on and less attractive for them to leave. Further, they noted that the work of the National Lab scientists and researchers is, by nature, very focused on basic scientific research. The scientists may prefer this type of work over the very different kind of research required to move experimental science to market application. Many scientists and researchers may also prize the prestige, pay, pension, and other benefits of employment in a National Laboratory, when compared to the perceived risk involved in participating in a new private venture. There may be other challenges as well, including those related to conflict-of-interest issues, that are difficult for staff to overcome in order to get approval to work with outside collaborators.

The fourth set of issues described concerns the constraints of existing budgetary and legal terms that frame technology transfer. Technology transfer leads interviewed pointed out that, even in cases where the opportunity for the commercialization of research is evident, supporting funds may not be available; the lab's technology transfer office, which is funded from the lab's overhead account, may be limited in terms of what projects can be funded, over what period of support, and over what terms of engagement. Existing funding vehicles, such as the Technology

Commercialization Fund, which have had a very high private matching requirement, may not have been sufficiently supple to encourage some types of collaborations with outside actors to move new technologies to the market. [186]

Together, these issues highlight the complex and interlinked challenges preventing a more effective technology transfer process from the DOE labs. Foundations can play a limited role in addressing some of these challenges. For example, and depending on the circumstance, they may be able to coordinate support from private philanthropies to fund serendipity-based research that lies outside of what is programmed within lab budgets. Indeed, such a role is already being undertaken by the foundation associated with the Berkeley National Laboratory. Chapter 5 draws out this opportunity, as well as others, for foundations in the technology transfer process.

DOE has sought to address some of the broader operational and policy issues raised in this context of the DOE-laboratory relationship through the CRENEL and SEAB reviews, though these efforts have viewed the issue primarily in terms of the traditional technology transfer paradigm. To broaden the perspective, this report turns next to describe the DOE research and development system through its linkages to the broader innovation ecosystem.

## 4.4 Enhancing Ecosystem Engagement

The shift from a linear model of innovation to an ecosystem-based paradigm implies significant change in how technology transfer is considered. The linear approach (moving from basic research to applied research to technological development and market deployment) is gauged through a focus on measuring numbers of patents, licenses, cooperative agreements, and start-ups.[187]

**Figure 4. 4: The Linear Model of Innovation**


(Source: Balconi, Brusoni, Orsenigo (2010))

With an ecosystems approach, the process of commercializing new technologies lives within networks of cooperation among a variety of actors, including small and large firms, research organizations, universities, banks, angels, and venture capital firms that collectively form an innovation ecosystem.[188] This means that building and sustaining innovation ecosystems are an integral part of technological innovation, knowledge-based economic development, and regional and national competitiveness. Understanding and encouraging this process requires moving beyond counting intermediate outputs to capture network effects. Figure 4.5 provides one

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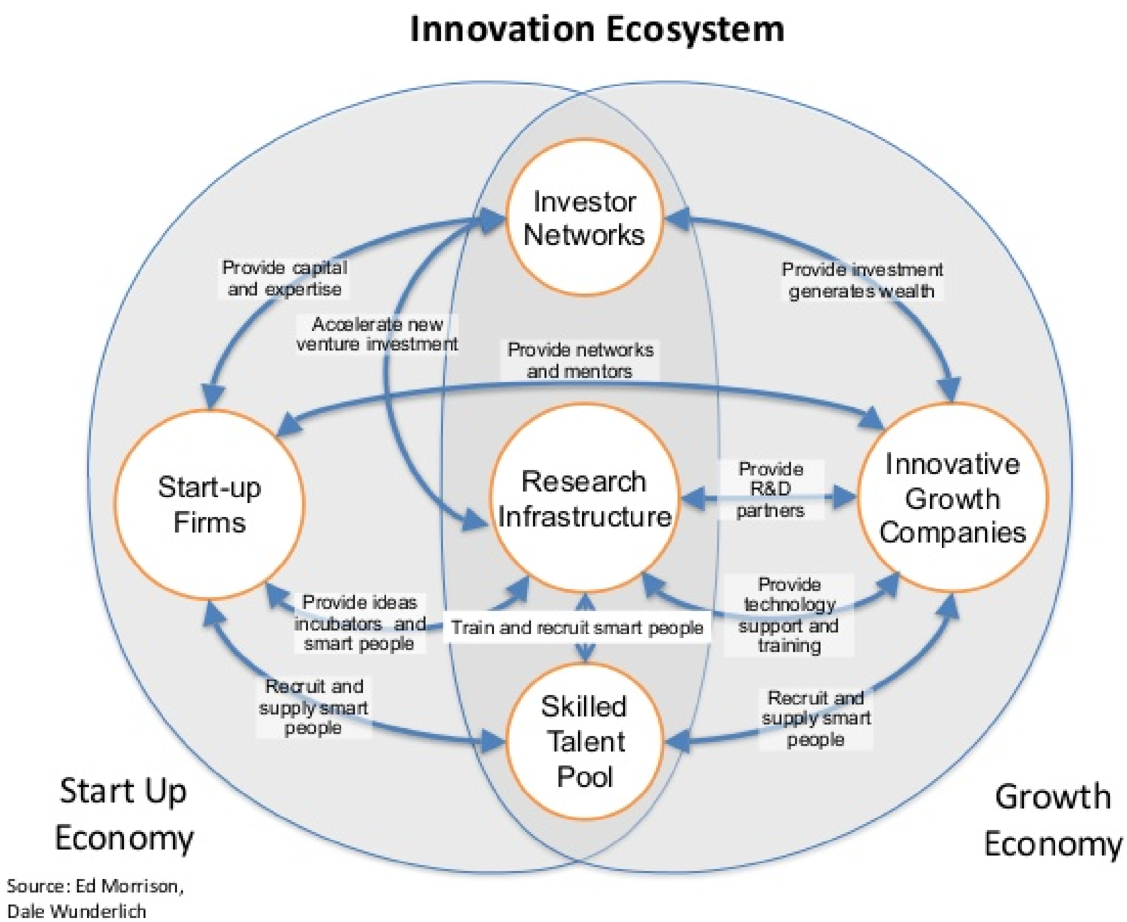
[186] Now addressed in legislation with reference to EPACT 2005 Sec 988, consistent with other DOE cost share efforts. (P.L. 116-260)

[187].Margherita Balconi, Stefano Brusoni, and Luigi Orsenigo, "In Defence of the Linear Model: An Essay," *Research Policy* 39, no. 1 (February 2010): 1–13, https://doi.org/10.1016/j.respol.2009.09.013.

[188] Shivakumar, S. (2017). 'Innovation as a Collective Action Challenge.' In P. Aligica, P. Lewis, and V. Storr (eds.), The Austrian and Bloomington Schools of Economics. Advances in Austrian Economics, Volume 22.

depiction of the complex relationships among a limited variety of actors within an innovation ecosystem.[189]

**Figure 4.5: Example of an innovation ecosystem diagram**




(Source: Morrison and Wunderlich (2016))

The DOE labs have long participated in ecosystem building through a variety of programs that encourage start-up entrepreneurship and connect their research with industry, universities, and state and local governments. These multi-layered, decentralized, and often-overlapping series of programs, activities, and policies serve to encourage public-private collaborations and foster the network of relationships that catalyze innovation.

These programs and activities, leading examples of which are briefly introduced below, may offer opportunities for the labs to further enhance their ecosystem-building role. More detailed summaries are provided in Appendix E.

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189 Morrison, E. & Wunderlich D. (2016). Moving our innovation thinking from barriers to ecosystems. Retrieved from http://www.edmorrison.com/moving-our-innovation-thinking-from-barriers-to-ecosystems/

### *4.4.1 Encouraging Entrepreneurs and Small Businesses*

DOE and the labs employ a variety of mechanisms to encourage entrepreneurship by variously providing researchers access to lab facilities, by soliciting small businesses to address technical challenges associated with lab missions, by providing lab researchers training and exposure to business practices, and by providing entrepreneurial leave to allow some lab researchers to commercialize their ideas. These mechanisms connect the lab in various ways to small and large businesses, venture firms, and universities and research organizations, helping to grow out an innovation ecosystem.

*The Lab Embedded Entrepreneurship Program*: This program embeds leading young talent within DOE's world class research and development facilities. The program, currently active at Cyclotron Road (based at Lawrence Berkeley National Laboratory), Chain Reaction Innovations (based at Argonne National Laboratory) and Innovation Crossroads (based at Oak Ridge National Laboratory), provides post-doctoral researchers a stipend as well as project dollars to pursue research projects towards commercialization. Importantly, they also provide access to the labs' world-class research tools, equipment, facilities, and expertise, and facilitate additional collaborations with peers, mentors, executives, investors, entrepreneurs, philanthropists and other experts from academia, industry, government, and finance. This interaction of lab researchers with these embedded researchers also enriches the work of the laboratories.

*The Small Business Innovation Research Program (SBIR):* SBIR, along with the Small Business Technology Transfer program (STTR) at DOE, prioritizes the potential for entrepreneurs to contribute new approaches and technologies to advance the missions of the DOE. In its 2020 review of the program, a committee of the National Academies of Sciences, Engineering, and Medicine found that "the DOE SBIR/STTR programs, together, are a critical element within the broader American energy innovation system."[190] In addition to providing, at the early-stage of development, non-diluted equity to small innovative firms seeking to commercialize ideas born in the labs, the competitive vetting process for SBIR/STTR awards also serves as a signal for private investors of the technological potential and commercial promise of the innovation, drawing in additional investment. This crowding-in effect further builds out the innovation ecosystem.

*The Advanced Research Projects Agency-Energy Program*: ARPA-E's authorizing statute states that its mission is "to overcome long-term and high-risk technology barriers in the development of energy technologies," and help ensure that "the United States maintains a technological lead in developing and deploying advanced energy technologies."[191] Exempting ARPA-E from many federal rules and regulations, the Act also deliberately attempts to structure the agency to be different from other Department of Energy (DOE) offices or programs to allow for operational flexibility. The director of ARPA-E is responsible for achieving the agency's statutory goals through targeted acceleration of "novel early-stage energy research with possible technology applications" and "advanced manufacturing processes for the domestic manufacturing of novel

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[190] National Academies of Sciences, Engineering, and Medicine. SBIR/STTR at the Department of Energy. Washington, DC: The National Academies Press, 2016. https://doi.org/10.17226/23406.
[191] 42 U.S.C. § 16538
"42 U.S. Code § 16538 - Advanced Research Projects Agency—Energy," LII / Legal Information Institute, accessed November 9, 2020, https://www.law.cornell.edu/uscode/text/42/16538.

energy technologies." The Act emphasizes that ARPA-E is expected to pursue those research technology themes and specific ideas that industry is not likely to undertake by itself.[192]

*Small Business Vouchers:* Pioneered by DOE's Office of Energy Efficiency and Renewable Energy (EERE), small business voucher programs open the labs to qualified small businesses by making the contracting process simple, lab practices transparent, and access to the labs' unique facilities affordable. The vouchers help small business overcome challenges with prototyping, materials characterization, high-performance computations, modeling and simulations, and validation of technology performance, among others. Simplifying the contracting process can enhance access but, paradoxically, also make it less flexible. Even so, the exposure of the lab researchers to technical issues in commercialization and experience in working with small businesses is of benefit to the labs and to DOE.

*Energy I-Corps*: This initiative of the Office of Technology Transitions, pairs teams of researchers with industry mentors for an intensive two-month training where the researchers define technology value propositions, conduct customer discovery interviews, and develop viable market pathways for their technologies. Researchers return to the lab with a framework for industry engagement to guide future research and inform a culture of market awareness within the labs.

*Sandia's Entrepreneurial Separation to Transfer Technology Program:* This program at Sandia National Laboratory allows its employees to work in the entrepreneurial world, guaranteeing their reinstatement if they return within two years. A third-year extension can be requested. Researchers can take a licensed technology, often one they invented, to the private sector, or bring a skillset or expertise to a startup or existing company. The program helps lower the risks to would-be lab-researchers turned entrepreneurs to try something new, and returning researchers bring back new skill sets and perspectives to Sandia.

### *4.4.2 Facilitating Collaboration with Industry*

The DOE and the labs have experimented with a variety of innovative mechanisms to make collaboration with industry easier, faster, less expensive, and more effective. These mechanisms, which provide benefits both to industry and to the lab, include cooperative research and development agreements, umbrella legal agreements, and partnership projects where the labs perform contract work for industry.

*Cooperative Research and Development Agreements (CRADA):* A CRADA is an agreement between a government agency and a private company or university to work together on research and development. This form of collaboration provides non-federal entities benefits in terms of subject matter interventions and access to STEM expertise within the DOE National Laboratory network, while providing opportunities for the labs to optimize their resources. Lab contributions to the CRADA can take the form of expert staff, state-of-the-art facilities, equipment, and other resources, although the National Laboratory cannot provide funds to the other participant. Non-

[192] National Academies of Sciences, Engineering, and Medicine. An Assessment of ARPA-E. Washington, DC: The National Academies Press, 2017. https://doi.org/10.17226/24778.

federal participant contributions can take the form of funds, personnel, facilities, equipment, and other in-kind resources.

*Enabling Legal Frameworks:* Many labs are employing innovative legal agreements and frameworks to ease barriers to negotiation and cooperation. Lawrence Berkeley's umbrella CRADA, for example, works to streamline the features and approval processes that are used by a number of the labs in their cooperative research and development agreements with industry. Other labs employ similar instruments to streamline processes.

*Strategic Partnership Projects (SPP):* These agreements cover work for others performed by a DOE contractor for Federal, State, and local government entities, non-Government/non-profit entities, universities, and privately held corporations. This work is not directly funded by DOE but is authorized by and administered by DOE; the external partner reimburses a DOE lab for R&D work. While SPPs can be an additional source of funding for the labs, they moreover provide industry access to the highly specialized and unique technical expertise and equipment that is not available elsewhere. Services provided by DOE related to characterization and modelling can help transfer technology developed by the labs, thus promoting commercialization of laboratory technologies by industry.

*Agreement for Commercializing Technology (ACT):* Another mechanism, the ACT, now used by the M&O contractor of Brookhaven National Laboratory and other M&O contractors, seeks to make legal negotiations between non-federal entities and the lab's contractors more flexible and timelier. The ACT agreement frameworks can help reduce uncertainties for the external partner regarding performance, liability, and payment that may arise in the context of CRADA and SPP agreements while assuring that all government requirements are met. In this way, ACTs can attract potential partners who previously may not have been able to do business with a lab.

As a leading example of this flexibility, the Alliance for Sustainable Energy, LLC, the M&O contractor of NREL and the Wells Fargo Foundation are partnering under ACT to take promising energy efficiency innovations, de-risk them, and deliver them to the market to accelerate the transition to a low-carbon economy. This multi-million, multi-year agreement enables the Wells Fargo Foundation, through its Innovation Incubator (IN2) program, to fund and support innovative renewable energy technologies and energy efficiency start-up companies.

*Membership Programs:* Another CRADA-centered model is CalCharge, a membership program comprised of new and established firms, labs, and other research organizations that sponsors hackathons, supports start-ups with matchmaking and commercial potential, and connects pilot projects with corporate partners.

*Partnership Platforms:* The Illinois Accelerator Research Center at Fermilab, for example, encourages scientists and engineers at the labs to work side by side with industrial partners to develop a variety of applications. (The center also collaborates with local universities and serves as a training facility for a new generation of scientists, engineers and technical staff in accelerator technology.) In a similar vein, the High-Performance Computing Innovation Center at Lawrence Livermore gives companies a platform to partner with the lab's computational R&D experts on projects that call for advanced modeling and simulation, virtual prototyping and testing, advanced manufacturing, data analysis, and more.

*Technology Consortia:* U.S. companies often struggle with the complexity and time required to identify research and development capabilities at the various labs, and with the difficulty of formalizing teaming agreements. Consortia such as LightMAT, a network of 10 DOE labs with technical capabilities highly relevant to lightweight materials development and utilization that is managed by PNNL, can provide a one-stop shop for industrial researchers who want to use the unique capabilities and talents found at select DOE labs.

*User Facilities:* A user facility is a federally sponsored research facility where external users can advance scientific or technical knowledge using advanced tools such as accelerators, colliders, supercomputers, light sources, and neutron sources, as well as facilities for studying the nano-world, the environment, and the atmosphere. Facilities are open to all potential users without regard to nationality or institutional affiliation, subject to applicable access reviews, and the allocation of facility resources is determined by a merit review of the proposed work.

*Non-proprietary User Agreements* are used for non-commercial research. Here, researchers pay for their own costs of the research with the DOE laboratory and gain access to specialized laboratory equipment and permission to collaborate with laboratory scientists. Proprietary User Agreements are used for commercial research. Under this type of agreement, the user pays the full cost associated with the use of specialized laboratory equipment and, with limited exceptions, retains as proprietary the technical data generated, as well as the rights to any new inventions.

The distinguishing feature between Non-proprietary and Proprietary User Agreements is the exchange: Non-proprietary users do not need to provide the lab any funding and in exchange, they agree to publish data arising from the research. In contrast, the proprietary user that wishes to maintain confidentiality of the data reimburses the lab for use of the facilities and any expertise. They are not required to publish data, hence "proprietary."

According to the DOE's Office of the General Counsel, there are at present thirty-nine designated user facilities that support research across DOE. Table 4.6 lists the designated user facilities by laboratory. The term "designated" refers not to supporting research but to designation for use of User Facilities Agreements and patent class waivers (both Proprietary and Non-Proprietary.) This list does not present a complete list of facilities known as "User Facilities."

**Figure 4.6: DOE National Laboratory Designated User Facilities**

| Laboratory Name | User Facility |
|---|---|
| Multiple Laboratories | 1. ARM Climate Research Facility |
| Argonne National Laboratory | 2. Advanced Photon Source |
| | 3. Electron Microscopy Center for Materials Research |
| | 4. Argonne Tandem Linac Accelerator System |
| | 5. Center for Nanoscale Materials |

| Laboratory Name | User Facility |
|---|---|
| | 6. Argonne Leadership Computing Facility (ALCF) |
| Brookhaven National Laboratory | 7. National Synchrotron Light Source (NSLS) |
| | 8. Accelerator Test Facility |
| | 9. Relativistic Heavy Ion Collider (RHIC) |
| | 10. Center for Functional Nanomaterials |
| | 11. National Synchrotron Light Source II (NSLS-II) |
| Fermi National Accelerator Laboratory | 12. Fermilab Accelerator Complex |
| Idaho National Laboratory | 13. Biomass Feedstock National User Facility |
| | 14. INL Wireless National User Facility (WNUF) |
| | 15. Idaho National Laboratory Advanced Test Reactor** |
| Lawrence Berkeley National Laboratory | 16. Energy Sciences Network** |
| | 17. Joint Genome Institute - Production Genomics Facility (PGF)** (joint with LLNL, Los Alamos National Laboratory (LANL), ORNL and PNNL) |
| | 18. Advanced Light Source |
| | 19. National Center for Electron Microscopy (NCEM) |
| | 20. Molecular Foundry |
| | 21. National Energy Research Scientific Computing Center (NERSC)* |
| | 22. 88inchcyclotron*** |
| Los Alamos National Laboratory | 23. Lujan at Los Alamos Neutron Science Center |

| Laboratory Name | User Facility |
|---|---|
| National Renewable Energy Laboratory | 24. Energy Systems Integration Facility |
| Oak Ridge National Laboratory | 25. Building Technologies Integration and Research Center |
| | 26. Center for Nanophase Materials Sciences |
| | 27. High Flux Isotope Reactor |
| | 28. Manufacturing Demonstration Facility |
| | 29. National Transportation Research Center (NTRC) |
| | 30. Spallation Neutron Source (SNS) |
| | 31. Oak Ridge Leadership Computing Facility (OLCF) |
| Pacific Northwest National Laboratory | 32. Environmental Molecular Sciences Laboratory (EMSL) |
| | 33. Molecular Science Computing at EMSL |
| Princeton Plasma Physics Laboratory | 34. National Spherical Torus Experiment (NSTX) |
| Sandia National Laboratory/Los Alamos National Laboratory | 35. Center for Integrated Nanotechnologies |
| SLAC National Accelerator Laboratory | 36. Stanford Synchrotron Radiation Laboratory (SSRL) |
| | 37. LINAC Coherent Light Source |
| | 38. Facility for Advanced Accelerator Experimental Tests, Thomas Jefferson National Accelerator Facility |
| | 39. Continuous Electron Beam Accelerator Facility |

(Source: DOE Office of the General Counsel)

*In addition to offering both of the user class waivers, certain industrial users may qualify for a special user agreement available at these supercomputing facilities.
**These user facilities only offer the non-proprietary user agreement.
***This facility can only offer the proprietary user waiver but is not a designated Office of Science user facility.
****Pending finalization of Implementation Plan.

### 4.4.3 Cooperation with Universities

Linkages between universities and DOE labs take place in multiple contexts. In many instances, a university holds the M&O contract and thus partners with DOE in the operation of the lab. DOE also supports university research directly (i.e., not through the labs) and many DOE labs maintain close relationships with numerous universities (beyond their M&O contractors.)

DOE National Laboratories collaborate with colleges and universities through multiple channels. These include mechanisms previously noted such as Cooperative Research and Development Agreements, Strategic Partnership Projects (SPPs), and the Lab Embedded Entrepreneurship Program. Lab contractors may also engage with external partners through Agreements for Commercializing Technology.

Many of the science labs, notably, maintain close relationships with universities, including SLAC with Stanford University, Berkeley National Laboratory with the University of California at Berkeley, Ames National Laboratory with Iowa State University, and Argonne National Laboratory with the University of Chicago. Lab-university linkages take many forms including employee education, joint appointments, fellowship programs, and postdoctoral research. University partnerships also connect the National Laboratories with a steady flow of newly trained talent and expertise.

While many of these relationships are forged with the science and engineering departments of the partnering university, cooperation also extends to participation in university-based accelerators and incubators and with business and entrepreneurship schools. The Polsky Center for Entrepreneurship and Innovation at the University of Chicago, for example, administers programs that embed students of business administration and entrepreneurship at Argonne and Fermilab. Additionally, the DOE labs are increasingly partnering with universities as collaborators in projects funded by other, non-DoD sources, as well (particularly including DHS, DOD and DTRA). The mechanisms for such collaboration vary, often including separate funding to the partners or external funded projects to the university which are coupled with DoE funding sources for greater scientific impact.

### 4.4.4 Cooperation with State and Federal Programs

Several DOE labs also cooperate with state and federal programs in supporting regional economic growth. Two examples follow:

Pacific Northwest National Laboratory (PNNL)/*Washington State:* Marine energy experts at PNNL are partnering with Washington Maritime BLUE 2050—a public/private alliance with support from Washington state and the U.S. Economic Development Administration—to accelerate innovation in the state's maritime industry. Washington state's strategy is to assert itself as a global leader in innovation and sustainability in what is expected to be, by 2030, a $3 trillion global industry. PNNL assists in this strategy by studying novel methods for generating hydrogen from renewable resources, working with local ports as they shift towards electrification, and helping coastal communities become more resilient in the face of an uncertain climate.

Sandia National and Los Alamos National Laboratories (*SNL-LANL); New Mexico:* Los Alamos and Sandia National Laboratories in partnership with the State of New Mexico have launched the

New Mexico Technology Readiness Gross Receipts Initiative (TRGR) to advance technologies derived from New Mexico National Laboratories to be market ready. The program gives businesses in the state the opportunity to work directly with scientists and engineers at Los Alamos or Sandia National Laboratories to advance the maturation of patents, patent applications, and software. Applicants must have licensed a technology from one or both New Mexico DOE labs or participate in a CRADA with Los Alamos or Sandia National Laboratories. The work involved may include prototyping, proof-of-concept and technical validation among other approved activities. Under the program, New Mexico businesses may receive up to $150,000 worth of assistance (cost of labor/materials for National Laboratory staff) from the State of New Mexico per year.

## 4.5 Understanding Outputs

The labs and DOE programs are connected to a variety of external actors through a diverse suite of technology transfer mechanisms. Chapter 3 summarizes the various technology transfer metrics related to the generation of patents, licenses, cooperative agreements, and start-ups in aggregate terms. Regarding adding up these transactions, DOE is generally considered to be a leader among its peers.

To highlight, in FY 2018, DOE and its National Laboratories and facilities managed and executed 16,209 technology transfer related transactions. These transactions include but are not limited to 1,011 Cooperative Research and Development Agreements; 2,352 Strategic Partnership Projects (SPP); 447 CRADAs with small businesses; and 4,742 total active licenses. There have also been 16,209 user projects awarded to date of which 189 and 298 are awarded to small businesses and industry, respectively.

In addition, in FY 2018 DOE National Laboratories and facilities disclosed 1,588 inventions; filed 1,144 patent applications (962 U.S. and 182 foreign); were issued 822 patents (693 U.S. and 129 foreign); and commercialized 482 technologies. Associated with these activities, DOE's National Laboratories and facilities reported approximately $235.1 million in SPP non-federal sponsor “funds-in,” $64.3 million in non-federal sponsor “funds-in” for CRADAs, $29.0 million in non-federal sponsor “funds-in” for ACTs, $37.8 million in licensing income, and nearly $23.3 million in earned royalties. Further there are several unique small businesses collaborating with the labs, startup companies, and active material transfer agreements.

What is less well understood is how these activities, as well as those related to partnerships with industry, universities, and state and local governments, combine to contribute to the development of innovation networks. A better understanding is also needed on how the characteristics of these networks affect the potential trajectories of technologies of varying types and complexity to develop and scale up on the journey from idea to market.

Technology transfer measures that focus on intellectual property rights revenue and the like do not capture the full complexity of the process of commercialization. A fuller picture can emerge by analyzing DOE’s data to help identify gaps and opportunities, develop a strategy, and enhance and build out existing networks of cooperation. Such data analysis can extrapolate outcomes from the outputs that are needed to understand impacts. The data here are not limited to the counts of outputs but rather the resulting R&D from each engagement or project, cumulatively.

However, DOE does not yet systematically map the impact of its suite of programs, activities, and initiatives through time and across the actors in various U.S. regions. Federal SBIR awards, for example, are not comprehensively tracked through time to allow for an understanding of the trajectory of technologies. Data collected also do not capture the secondary impacts that new technologies and firm growth have on employment and economic growth.

Some of this type of follow-on analysis is already possible and DOE publishes reports on the economic impacts of some individual labs.[193] DOE collects data on the relationships that its labs and programs have with other regional and national actors, including firms, universities and research institutions, and other non-governmental organizations. DOE has already demonstrated through pilot initiatives that this data can be used to develop innovation cluster maps, but for lack of funding, this work has not been expanded. Still to be explored is the question of how such mapping can be used as a tool to enhance DOE's ability to foster innovation and manufacturing ecosystems.

## 4.6 The Foundation Role

DOE's mission is facing a period of adjustment—similar to post-WWII era and the 1970s—as it responds to new global rivals and competitors, climate change, new technologies, and changing domestic economic and energy needs. In current times, it is no longer sufficient to just move new ideas, technologies, manufacturing processes, materials, and supply chain simulations out of the labs in the hope that they find fertile soil for development and commercialization within the United States. The growth of competitive innovation systems around the world means that ideas developed with federal funding within the labs can easily move overseas for further development and manufacture, reducing the return to the nation on its public investments in scientific research.

In addition, the atrophy within numerous domestic innovation and manufacturing networks, partly the result of decades of offshoring manufacturing, means that the labs are increasingly seen as a tool to help renew and regenerate the health, vigor, and absorptive capacity of the U.S.-based innovation ecosystems into which technology is being transferred. This includes the task of successfully identifying and pursuing the multiple potential (often, not obvious or anticipated) applications of a given technology. For competitive and national security reasons, the United States needs to remain a preeminent center for research and manufacturing across a range of emerging technologies among the set of globally interconnected innovation economies.

In many respects, the labs are already engaged in aspects of this new mission through a variety of programs that foster entrepreneurship and build connective networks with industry, universities, and state and local governments. Complementing this effort are three lab-associated foundations that variously provide outreach to the communities surrounding the lab facilities, network with philanthropies to support new areas of research that may lie outside the lab's missions and reinforce the development of a regional talent and skills base.

*The Los Alamos National Laboratory Foundation*: The LANL Foundation was created in 1997 by contractor leadership at Los Alamos National Laboratory, the University of California, the

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193 For example, the economic impact of Sandia National Lab is published here: http://www.mrcog-nm.gov/DocumentCenter/View/4315/SSandTP_EIA_2020_0615_final-PDF

Department of Energy, the Los Alamos Public Schools, and the New Mexico Congressional Delegation to support public schools and public-school children in the vicinity of Los Alamos National Laboratory. Serving the seven-county region of North-Central New Mexico including Los Alamos, Mora, Rio Arriba, Sandoval, San Miguel, Santa Fe, and Taos Counties, a key objective of the foundation is to strengthen the capacities of the tribal and pueblo communities that surround LANL, primarily through support for children and families.

The foundation collaborates with these communities to improve early childhood learning, inquiry-based science and STEM learning, and scholarship. Seeking to increase K-12 student access to well-qualified and experienced educators and robust educational opportunities, the foundation works to strengthen school and district systems, teacher preparation, and professional development.

*Berkeley Lab Foundation:* The Berkeley Lab Foundation was established in 2013 by the University of California to promote corporate and philanthropic engagement in support of Berkeley Lab's mission. It serves as the bridge between Berkeley Lab and donors who wish to support its multi-disciplinary research. By supporting projects in the early stages of development, donors enable Berkeley Lab to amplify promising new research that can lead to the transformative discoveries for which Berkeley Lab is known.

In some cases, these leads emerge from but are tangential to the lab's research agenda—which means that they are not able to secure additional funding from within the lab's existing budget framework. Recently, for example, the Berkeley Lab Foundation received grant funds from the Gordon and Betty Moore Foundation to support the development of a unique microscopy concept pioneered by researchers at Lawrence Berkeley National Laboratory. The foundation then initiated a SPP to support the principal investigator of this project. In this way, the foundation advances research at the lab, while advancing the Moore Foundation's programmatic interest in equipping the scientific community with the tools and infrastructure needed to investigate symbiosis in aquatic microbes.

*The Livermore Lab Foundation:* LLF was formed in 2016 to provide opportunities for philanthropic support of scientific research, innovative technology and educational endeavors at Lawrence Livermore National Laboratory. It was established with the aim of advancing fundamental knowledge, creating transformative technologies, and enhancing human health, safety, and quality of life for current and future generations. The foundation also supports STEM learning initiatives aligned with the Laboratory's educational, and science priorities.

In addition to supporting scientific and technological projects at LLNL, the foundation also uses its resources to fund external activities and programs that its board views as consistent with LLNL's values. This includes sponsoring STEM student scholarships and donations of lab supplies to local schools, as well as other external efforts that support the growth of scientific passion and curiosity in the community. For example, LLF has helped to support the region's Girls Who Code event.

LLF operates as a 501(c)(3) tax-exempt charitable organization that can accept donations from the public -- including individuals, businesses, colleges and universities and other charitable foundations. Although it does receive administrative and financial support through a contractual arrangement with the University of California, which is also the M&O contractor for the Lawrence Livermore National Laboratory, LLF is separate and independent from LLNL and the University of California, just as other lab-associated foundations are separate and independent from the associated lab and its M&O contractor. Donations to the Livermore Lab Foundation may be "restricted" (dedicated to a certain project or topic) or "unrestricted" (available for use at the discretion of the LLF board of directors).

These lab-associated foundations demonstrate an intent to craft intermediating organizations that can connect the unique capabilities and resources of a very diverse set of DOE labs to develop regional and national innovation networks. In turn, these networks can also support the mission of the labs by fostering the regional talent and skill base, by creating vibrant supplier networks, and by encouraging greater public support for its work. These lab-associated foundations, however, are relatively new organizations and have not yet developed a sufficient track record that can be assessed.

While these foundations have the advantage of being attuned to the unique characteristics and needs of the labs with which they are associated, they also face some limitations stemming from their small scale of operation and relative isolation. Chapter 5 considers the role that a DOE foundation can play in complementing the work of the lab associated foundation. As we see next, a DOE foundation can *inter alia,* provide a forum where lab associated foundations can network to share knowledge and respond as a system to cross-cutting national challenges. These and other concepts are further developed for DOE with a thorough analysis of the experiences of other agency-based foundations as possible points of reference and examples of best practices.

# Chapter 5: A DOE Innovation Foundation

As the nation confronts new competitive and security challenges in the twenty-first century, DOE and the National Laboratories face the need to adapt and renew their strategies and missions. Addressing these challenges calls for expanding the concept of technology transfer—from one that focuses on moving research ideas from the lab to the marketplace to one that embraces a broader role for DOE and the labs in revitalizing science and innovation networks across the nation. This report looks at the ways by which a national foundation could assist in this new charge.

Recognizing the breadth and multiple aspects of the DOE complex and the extent of its current technology transfer activities, this report addresses how a foundation can both supplement and complement the existing technology transfer toolkit utilized by DOE and its National Laboratories. It examines DOE's current challenges in accelerating innovation and explores how a national foundation might address those challenges. Importantly, by examining the experience and record of accomplishment of other federal agency-related nonprofit research foundations, this report illustrates both the potential roles that a DOE foundation can play and how it can be designed, organized, and administered.

As discussed in preceding chapters, the Academy observed that foundations perform a variety of roles that can complement the missions of diverse federal agencies. In addition, there are at present three DOE lab-associated foundations that engage with the private sector and philanthropic community to raise funding, conduct training, research, and education, attract talent, and engage with the public— all in support of the agency's broader goals. The roles and experiences of these agency affiliated foundations inform the Academy's recommendation regarding the value of a network model for DOE that combines both lab-associated foundations and a complementary DOE foundation.

Chapter 5 provides a summary of the salient observations from each of the preceding chapters, along with the attendant findings and recommendations as they are supported in each chapter. As a result, the order of the findings and recommendations in chapter 5 differs from the sequence in the Executive Summary, which lists the recommendations in order of importance.

## 5.1 Study Assumptions

In evaluating the potential value of a DOE foundation, the Academy adopted several basic study premises or assumptions:

- **The study assumes a broad and inclusive definition of technology transfer:**

  Recognizing DOE's multiple missions and the department's diverse range of technologies with varying technology maturity, the Academy adopted a broad and inclusive view of technology transfer including traditional metrics, knowledge transfer mechanisms engagement with local communities, promoting STEM education among underrepresented communities, and workforce development. Taken together, this approach recognizes that technology transfer takes place in the context of an innovation ecosystem and that an effective technology transfer strategy must also participate in enhancing the health of this ecosystem.

- **The study is an independent and neutral assessment:**

Throughout its field research, including interviews and focus group sessions, the Academy adopted a neutral approach--it did not advocate for the creation of a foundation or any specific model or structure.

- **The study calls for a multi-dimensional approach:**

  The Study Team recognizes that a DOE foundation is one of several congressional initiatives to promote the commercialization of innovative DOE technologies. For a foundation to be successful, DOE leaders and Congress will need to pursue additional legislative and policy initiatives.

  Further, in evaluating the potential value of a DOE foundation, the Academy did not attempt to identify or to solve any particular problem related to DOE technology transfer activities. The study asks what more can be done and how a foundation might complement and supplement current activities.

- **The study assumes that the foundation's enabling legislation would provide the requisite funding, governance, and structural attributes:**

  If a DOE foundation were to be created, the enabling legislation must provide the requisite funding for administrative and operational costs, structure, and governance for the foundation to be successful.

## 5.2 Understanding the Foundation's Role

The task of exploring the potential value of a foundation for DOE to promote technology transfer starts with understanding the organizational context, governance, and potential roles of an agency foundation. In this regard, Chapter Two reviews existing congressionally mandated, federal agency-related nonprofit research foundations and corporations that may serve as potential models for a newly created DOE foundation. It examines the key attributes of successful agency foundations and their roles to support the mission of their related federal agencies.

### *5.2.1 Establishing a Sustainable Foundation:*

As Congress considers establishing a foundation to assist the Department of Energy in advancing its technology transfer and other related mission areas, there are several characteristics and lessons that can be learned from eleven other foundations examined.

**Legal Status:** A foundation is an entity that supports charitable activities by making grants to other organizations, institutions and/or engages in their own direct charitable programs. Many foundations utilize the tax-exempt status provided by Section 501(c)(3) of the Internal Revenue Code. This would allow donations to the foundation to be tax deductible, requires the organization to exist exclusively for charitable purposes and activities, requires the organization to not have a substantial part of its activities devoted to influence legislation, and more.

**Congressional Authorization:** Congress has legislated and enabled several foundations to assist government agencies in advancing their mission areas. These organizations take the form of quasi-governmental entities and have unique relationships with—but are also independent from—their respective federal agency.

Of the eleven agency foundations examined in this report, all are designated as 501(c)(3) tax-exempt organizations and ten were Congressionally authorized. Eight of the foundations were created with legislated language appropriating initial funds to the foundation. Their enabling legislation provides further guidance on the foundation's purpose and scope of activities, board design, governance mechanisms, independence, and oversight. Other initial key characteristics include structural components that are generally decided by a foundation's Board of Directors, including staffing, finances, and conflict of interest policies.

While foundations can help agencies better serve their missions, Congress can improve their sustainability and effectiveness by emphasizing some prerequisites in the enabling legislation. This includes provisions that emphasize:

- The importance of funding, both at inception and annually;
- The critical nature of appropriate governance and oversight mechanisms;
- The need to create a board of directors with diverse representation; and
- The need to include robust conflict of interest policies.

**Foundation Value for DOE:** A sustainable foundation must be of enduring value to its principal stakeholders within the partnering agency. Interviews with stakeholders across DOE programs and the labs underscored the premise that well-designed foundations can reinforce their respective agency missions. Specifically, they pointed out that a foundation can provide a flexible and efficient mechanism for establishing public-private R&D partnerships; enable the solicitation, acceptance, and use of private donations to supplement the work performed with federal R&D funds; facilitate the commercialization of federally funded R&D; further enable DOE programs and labs to attract and retain scientific talent, and enhance public education and awareness regarding the role and value of DOE-sponsored research and development.

The following findings and recommendations arise from the Academy's analysis in Chapter 2 of eleven other agency foundations:

**Finding :** Successful agency-related foundations share similar characteristics.

- They are provisioned with sufficient funding to stand up the foundation and continued funding to support administrative expenses.
- They have enabling legislation and governance that clearly articulates the broad mission, the scope of activities, and structure of the foundation, including the design of its board of directors; appropriate governance and oversight mechanisms; and comprehensive conflict of interest policies and procedures covering the relations among their board of directors, the agency and with potential and existing donors.

**Recommendation :** The Panel recommends that Congress and DOE leaders consider the design features of successful agency-related foundations as an integral component when drafting enabling legislation and in the implementation of a new agency foundation.

- This design should include properly structuring, staffing, governing, and funding the organization.

- The foundation should be provided the flexibility and authority to respond to unexpected and unanticipated opportunities.
- The enabling legislation should include a clear mission statement with a focus both on commercializing new technologies, as well as integration within regional and national innovation ecosystems. This role should not be overly prescribed to avoid unnecessary limitations of the foundation's activities.

### *5.2.2 Foundation Value for Private and Philanthropic Organizations:*

The Study Team gauged the potential interest of private sector and philanthropic entities in engaging with a DOE foundation. Interviews with potential funders and research into science philanthropy identified potential areas of collaboration:

- Funding for community development, public engagement, STEM education, and development of next generation leaders;
- Interest in funding for conferences and other learning environments;
- Helping small businesses scale up new technologies;
- Interest in reviewing the full diversity of DOE's technology portfolio to identify potential investment opportunities; and
- Developing an easier way of working with the DOE and one that would reduce overhead rates.

**Finding :** There is significant interest among private-sector and philanthropic funders to selectively collaborate with a DOE foundation.

- Philanthropic entities look for opportunities to make early investments in their areas of programmatic interest, serving as a catalyst for future investments from both the private and donor communities.
- These actors see a role for the DOE foundation as a connector. Areas of mutual interest include clean energy technology, emergent threats such as COVID and anthrax, the promotion of STEM education among underrepresented communities, and the commercialization of spinoff technologies.

**Recommendation** : The Panel recommends that the proposed foundation leaders actively engage and collaborate with the private sector and philanthropic organizations to assess common areas of interest and future collaboration opportunities, including but not limited to the following:

- Technologies developed in DOE labs and programs represent a diversified portfolio of value to potential donors and private sector entities.
- A foundation can serve as a pathway for DOE technology transfer to be made visible/accessible to foundations.

- In this regard, the foundation should build upon and work with OTT and serve as an enabling interface and intermediary.

## 5.3 The New Technology Transfer Opportunity

America's global competitiveness has long been driven by the nation's ability to capture the economic and national security benefits of emerging technologies resulting from such investments. The effectiveness of federal support of scientific discovery during World War II through research universities and government organizations vividly demonstrated the effectiveness of research-driven industrial development on national security and economic growth. Since World War II, the United States has led the world in research investments, technology development, and industrial innovation. Under the "endless frontier" paradigm, federal funding for basic research has been the foundation for such progress. In FY2017, the Federal Government invested approximately $121 billion in research and development, approximately 40 percent at federal laboratories and 60 percent at universities and private sector R&D institutions.[194]

### *5.3.1 The New Global Imperative*

Today, that leadership is being challenged on a global scale by, among other factors, declining domestic manufacturing, the relocation of technology-intensive R&D abroad, and the changing rules around intellectual property development.[195] Of critical and immediate import for continued U.S. technological leadership is the scientifically accepted recognition of the adverse impact of climate change and the development of new competitive technologies, including those related to renewable energy, to mitigate and adapt to this change.

Congressional legislation and third-party studies have identified the significant contribution that DOE can play in addressing these global economic and environmental challenges facing the United States, by adopting new and enhancing existing mechanisms that utilize its scientific, technical and programmatic capabilities to fully deploy the results of its research, development, demonstration, and commercialization (see Appendix I: Additional Information Regarding Technology Transfer, Congressional Interest).

### *5.3.2 Heightened Congressional interest*

Over the past 40 years, Congress has demonstrated consistent interest in improving technology transfer from federal research institutions, and particular interest in the past 20 years in promoting the commercialization of clean energy technologies at DOE (see Appendix I: Additional Information Regarding Technology Transfer, Congressional Interest). This report was instigated by congressional interest in determining the value that a non-profit national foundation could provide to "assist the Department to advance its mission of addressing the nation's energy

[194] National Center for Science and Engineering Statistics, Accessed December 21, 2020 at https://www.nsf.gov/statistics/2020/nsf20309/nsf20309.pdf
[195] National Institute of Standards and Technology, *Return on Investment Initiative, Final Green Paper*. https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1234.pdf

challenges" in support of "the research, development, demonstration and commercial application of…innovative technologies" or "innovative energy technologies."[196]

In parallel during the 116th Congress, the "Impact for Energy Act" was introduced, proposing to add as a new capability in DOE's technology transfer tool kit, a nation-wide DOE affiliated non-profit Foundation, an authority now exercised by other federal agencies. An expanded version of the legislation was included in the Clean Economy Jobs and Innovation Act, passed by the House in September 2020 (see Chapter 3).

In addition, HR 5685, the "Securing American Leadership in Science and Technology Act of 2020," introduced in the House in January 2020, contains a provision to allow a "Government-owned Federal laboratory" to "establish or enter into an agreement with a nonprofit organization to establish a Federal laboratory Foundation in support of its mission."

As a result of its assessment the Academy has identified a number of distinct or new opportunities to advance DOE's technology transfer goals, and existing strengths and capabilities that should be reinforced. Building upon its survey of existing agency foundations, the Academy has proposed that a DOE foundation could play an initiatory or supplemental role in support of such efforts.

### *5.3.3 Broadening the definition of technology transfer*

As discussed in Chapter 3, during the duration of its research, the Panel learned that considering the on-going practice and analysis, the definition of "technology transfer" has evolved and broadened over the years. DOE's Office of Technology Transitions recently defined as its mission "to expand the public impact of the Department's research and development (R&D) portfolio to advance the economy, energy and national security interests of the nation."

**Finding*:*** The Panel recognizes the value of a broad concept of technology transfer as a multi-level approach, inclusive of the varied ways that knowledge, facilities, and technologies are diffused, disseminated, and deployed for public benefit through direct, indirect, and network pathway mechanisms.

**Recommendation :** The Panel recommends that a broad contemporary definition of technology transfer should be incorporated in the design of a foundation.

- The foundation should be tasked to implement modern technology transfer activities to potentially include, but not be limited to engagement with local communities, investments in startup companies to commercialize innovative technologies, promoting STEM education among underrepresented communities, and workforce training and development.

### *5.3.4 Encompassing the full range of DOE's mission capabilities*

As the analysis of DOE technology transfer performance in Chapter 3 revealed, all of DOE's organizations and program capabilities – including the extramural programs - contribute to the

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[196] U.S. House of Representatives Appropriations Committee, Conference Report on the Energy and Water Development and Related Agencies Appropriations Bill, 2020. https://www.congress.gov/congressional-report/116th-congress/house-report/83/1; U.S. Senate Appropriations Committee, Conference Report on the Energy and Water Development Appropriations Bill, 2020, 69. https://www.congress.gov/congressional-report/116th-congress/senate-report/102/1

fulfillment of the agency's mission, including an "all of the above" approach to clean energy, as demonstrated in the passage of the FY2021 appropriations act.

Discussions with DOE staff and stakeholders suggest that an optimal role of the proposed DOE foundation is one that would encompass all of DOE's non-classified mission space. A foundation can promote DOE as a model for other federal agencies, through for example, initiatives that increase the level of engagement with small firms, leverage the activities of extramural programs, advance STEM education in regional ecosystems, and promote workforce equity and diversity.

**Finding:** A widely acceptable role of a DOE foundation that would encompass all of DOE's non-classified mission space, thereby recognizing the potential contributions across all of DOE's constituent programs and organizational elements could make to achieve the proposed legislative purpose of a foundation.

**Recommendation:** In the design of a foundation, the full range of DOE's varied responsibilities, technologies, and research should be embraced in the Foundation's mission, consistent with the requirements of DOE's national security missions. [197]

### *5.3.5 Improving Technology Transfer at DOE*

Current technology transfer policy and practice at DOE has continually evolved as a result of four decades of legislation governing all federal agencies. It was further modified by specific DOE legislation, and as traditionally tracked, arising from R&D as performed by DOE's the labs, sites and plants. Over the past two decades, Congress has demonstrated consistent interest in enhancing DOE's capabilities to translate the results of its R&D into practical applications, with an increased focus on "clean energy applications."[198] Third party studies of the operations of DOE, and Congress in its numerous legislative proposals, recognize the centrality of National Laboratories in DOE's legacy of accomplishment.

- **Performance Models:** Federal technology transfer metrics for intramural research are statutorily prescribed and generally are limited to the linear model of 'basic research > invention disclosures > patent applications/awards >license agreements,' and through other mechanisms that engage the private sector such as CRADAs and user facility agreements. On these measures, DOE's performance makes it a leader among all federal agencies (see Appendix I: Additional Information Regarding Technology Transfer, Selected Agency Technology Transfer Metrics, FY 2016).
- **Performance Reviews:** DOE has also commissioned internal reviews of its performance, such as the SEAB, and cooperated with external studies such as those conducted by CRENEL and NAPA, which have identified organizational improvements. Such recommendations, and those generated by DOE staff, have been put into practice (see Appendix I: Additional Information Regarding Technology Transfer, DOE Commissioned Studies).

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[197] The Panel recognizes the classified activities of the labs require appropriate safeguards
[198] Chapter 3 of this report; 109th Congress, Public Law 109-58 "The Energy Policy Act of 2005". https://www.congress.gov/bill/109th-congress/house-bill/6/text; 115th Congress, Public Law 115-246 "Department of Energy Research and Innovation Act". https://www.congress.gov/bill/115th-congress/house-bill/589/text.

- **Metrics and Data:** DOE's Office of Technology Transitions annually collects 80 technology transfer metrics from DOE Labs, plants, and sites. This high-quality data set provides a rich source of information that is useful to identify new opportunities for external stakeholder engagement and internal process improvement. Congress has recognized the central role of OTT in recommendations to enhance the Office's role and has proposed elevating its organization.

**Finding:** A successful DOE Foundation depends upon a robust DOE-led technology transfer program, and the pathway for an enhanced DOE technology transfer program resides in the optimization of its current organizational structure and mechanisms by continued Congressional action and agency initiative:

- through continued internal process improvements,
- through broader legal authorities, dedicated funding, delegated and decentralized implementation,
- through tangible and visible incentives for the varied Labs through performance management metrics and similar accountability mechanisms, and
- through visible agency leadership at the highest levels.

**Recommendation:** A DOE foundation should identify and amplify those existing DOE and National Laboratory program activities where the foundation's mission and capabilities could add value to increase effective technology transfer, through for example, initiatives that increase the level of engagement with small firms, leverage the activities of extramural programs, advance STEM education in regional ecosystems, and promote workforce equity and diversity.

### *5.3.6 Illustrative Opportunities for a DOE foundation*

As the history of other agency-related foundations reveals, opportunities for a DOE foundation to add value will emerge over time, as new challenges present themselves, the organization develops distinct capabilities, and the stakeholder community responds with partnerships and resources.

In addition to the more well-developed sectors where a foundation could add value, the study Panel has identified some challenges upon which a foundation might initially focus its attention.

- **Improving Engagement with Small Technology Oriented Firms:** Small and young firms have difficulty engaging with federal research institutions, a particular problem for women and minority-owned firms. Although DOE has a better track record than other federal agencies, both outside studies and internal assessments, as well as the Academy's analysis of DOE provided data, suggest that an opportunity exists for increased engagement (see Appendix I: Additional Information Regarding Technology Transfer). A foundation may provide the vehicle for this engagement.

  "Small business" is generally defined by the SBA as under 500 employees, and although granular data was not available, it is likely that very small companies under 50 employees, which comprise the majority of business enterprises, are not well represented in the data on lab engagements reviewed by the Academy. The data does show, however, that DOE's level of engagement with small technology-oriented business—as generally defined—through mechanisms such as licenses and collaboration agreements is comparable to or superior to other federal agencies (see Appendix I: Additional Information Regarding Technology Transfer, Selected Agency Technology Transfer Metrics, FY 2016).

A recent study on collaboration between climate-technology start-ups and federal agencies points to the "surprising" finding that such collaborations enhance patenting and follow-on funding more than comparable collaborations with private firms and universities. However, the number of such engagements is a small fraction of the total number of engagements with private firms and universities.[199]

- **Amplifying the Impact of Extramural Programs:** DOE oversees a variety of extramural programs that support technology development and transition activities with third parties. In 2018 federal obligations in this sector totaled $3.995 billion, approximately 31 percent of DOE's total R&D budget of $12.832 billion. This list includes external facing programs such as SBIR, ARPA-E, and the Clean Energy Manufacturing Institutes, and other programs with universities, state and local governments, and private companies. Similar to the rigorous management regime that DOE utilizes with its National Laboratories, these programs exhibit close interaction with grant recipients that draw upon DOE's technical expertise to advance program objectives.
- **Promoting Workforce Diversity:** A third opportunity, common to federal scientific agencies, is to ensure equity, diversity, and inclusivity among its current workforce and in its employee pipeline and has been the subject of recent reports from such organizations as the NSF and NASEM.[200] There is also a visible and growing philanthropic interest in addressing climate change and its impact on communities.[201]

  Existing lab-associated foundations such as Lawrence Berkeley have played a role in addressing these issues (see Chapter 4), and other agency affiliated Foundations have addressed such matters within their respective mission spaces (see Chapter 2).

  The Study Team did not conduct a systematic review of DOE's activities in this space, but anecdotal comments during interviews indicated an interest and concern about this issue.

## 5.4 A Network Model for the DOE foundation

Having examined the roles that a foundation can play, this chapter now turns to how it can be designed and organized. The Panel calls for a networked model where lab-associated foundations and a DOE foundation work as complements.

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[199] Information Technology & Innovation Foundation, *Clean Energy Start-Up Companies*. https://itif.org/publications/2020/08/24/clean-energy-start-companies-are-most-likely-succeed-when-they-partner

[200] The National Academies of Sciences, Engineering, and Medicine, Advancing Diversity in the U.S. Industrial Science and Engineering Workforce. https://www.nap.edu/catalog/13512/advancing-diversity-in-the-us-industrial-science-and-engineering-workforce; The National Science Foundation, Diversity and Inclusion Strategic Plan (2012-2016) In Support of the Government-Wide Effort to Enhance Diversity and Inclusion in the Federal Workforce. https://www.nsf.gov/od/odi/reports/StrategicPlan.pdf

[201] The Washington Post, *Bezos makes first donation from $10 billion Earth Fund for fighting climate change*. https://www.washingtonpost.com/climate-environment/2020/11/16/bezos-climate-grants/

The Panel encourages initiatives underway at DOE to establish lab-associated foundations, of which three already exist.[202] As discussed below and in the preceding chapter, the lab-associated foundations have the advantage of being closer to the action, both in terms of the special characteristics, expertise, and facilities afforded by each lab and with regard to the opportunities present in their regions for collaboration with universities, firms, philanthropies, and state and regional governments. They can help grow regional innovation networks while also assisting core lab missions.

The Panel further recommends the establishment of a DOE foundation that would complement the activities of DOE, the labs and the lab-associated foundations. Acting as a common resource to the lab-associated foundations, the DOE foundation can—among other features— assist individual lab-associated foundations in cooperating with each other on projects of common interest, and it can potentially serve as a complementary funding source to scale-up some types of new technologies that have lengthy development cycles and high-cost structures.

### *5.4.1 Lab-associated foundations*

Lab-associated foundations can support the commercialization of research ideas across the diversity of lab activities and processes in multiple ways.

- **A lab-associated foundation can enhance the regional connectivity and external engagement** of **the labs**. Foundations associated with individual labs could serve as a regional node for diverse entities which bring different skills, experiences, knowledge, and resources to the innovation process. The study of extant foundations shows that they interact with philanthropic organizations, universities, and small and large businesses.
- **Lab-associated foundations can contribute to regional economic development.** As with the case of the Los Alamos foundation, they can help the lab reach out to their immediate communities through programs to encourage STEM learning. In another example, PNNL collaborates with Washington Maritime Blue to electrify the region's maritime fleet.
- **Lab-associated foundations are best placed to address the local realities facing each of the seventeen DOE National Laboratories**. As discussed in Chapter 4, DOE labs are a diverse set, varying by scale and location, by mission and type of contractor, by sources and levels of funding, and by the mix of basic, applied and national security related research that they conduct. While DOE guides the continual development of the labs and works to ensure that the labs maintain world-leading talent and capabilities, the labs are focused on their distinctive missions.
- **Lab-associated foundations can complement the unique structures, capabilities, and potentials of the labs by facilitating internal pathways.** As described in Chapter 4, the foundation associated with Lawrence Berkeley National

[202] Due to its status as a GOGO, NETL will require authority from Congress in order to establish a lab-associated foundation. In this regard, Congress has authorized federal labs to enter into special agreements for regional economic development purposes in concert with their technology transfer mission using Partnership Intermediary Agreements.

Laboratory helps to commercialize ideas born in the labs and by building out the innovation ecosystem.

- **Lab-associated foundations can reach out to Frontline Communities:** The Los Alamos Foundation, an exemplar, partners with local and state programs that reinforce K-12 education and build the skilled technical workforce. This outreach to economically distressed, frontline communities is an emerging national priority, identified in the Clean Economy Jobs and Innovation Act, and one that has not been a strategic and primary focus for federal agencies. These types of efforts can attract philanthropic support and, potentially, qualify for federal grants.
- **Lab-associated foundations can assist their labs to better cooperate with small (fewer than 25) and young (less than 5 years) firms.** Complementing existing programs—which often do not cater well to these fledgling firms—associated foundations can introduce entrepreneurial scientists and engineers to the expertise and equipment found in the labs. They can also assist small/young firms in procuring contract work at the lab.
- **The current set of lab-associated foundations illustrate how they can advance the mission of the labs.** As noted in Chapter 4, the Los Alamos Laboratory Foundation helps LANL to engage with the communities surrounding its facility. The Lawrence Livermore Foundation supports STEM learning initiatives aligned with LLNL's educational and science priorities. The foundation associated with the Lawrence Berkeley National Laboratory draws in philanthropic contributions to provide added budgetary flexibility for scientists to follow potential research opportunities.
- **Several DOE labs have expressed interest in establishing lab-associated foundations**. They have been encouraged by the experience of the current set of three lab-associated foundations regarding their ability to expand the impact of the lab research and development portfolios and their potential to promote the nation's energy and national security interests.
- **Lab-associated foundations may be limited in terms of their reach and scale of operation.** Lab-associated foundations, such as the Livermore Foundation, engage in limited fundraising, often focusing on their immediate community. They lack the resources to engage with potential donors on a large-scale basis.

**Finding:** Lab-associated foundations can help connect the unique capabilities and resources of each lab to other regional and national stakeholders. They can help both the government-owned and government-operated National Energy Technology Laboratory, and the government-owned and contractor-operated labs grow regional innovation networks while also improving the flow of technology transfer within the labs.

**Recommendation:** DOE should encourage, with Congressional action as may be required, the establishment of lab-associated foundations that are suited to the diverse characteristics, technical capabilities of individual labs, and the needs and resources found in the regional economy of each particular lab.

### *5.4.2 DOE foundation*

A networked system of lab-associated foundations can advance the missions of each of the elements in the network. A DOE foundation can provide this interconnection. The Study Team's discussions with DOE stakeholders and other policy experts identified potential roles for a DOE foundation.

- **A DOE foundation can assist individual lab-associated foundations in cooperating with each other on initiatives of common interest.** It can provide a platform for the lab-associated foundations to share best practices related to programs, assessments, and outreach. A DOE foundation can also serve as a tool for the lab-associated foundations to reach out to national and international expertise. In this regard, it can convene leading academics and business leaders in providing strategic guidance and thought leadership of issues of shared concern to lab-associated foundations. A DOE foundation can also serve as an additional means of informing lab-associated foundations of pertinent ongoing DOE work related to programmatic technology road-mapping, annual portfolio peer reviews, and strategic planning.
- **A DOE foundation can reinforce the activities of individual lab-associated foundations**. It can champion STEM education, workforce development, and overall community engagement initiatives carried out by lab-associated foundations. It can also provide technical help to the operations of lab-associated foundations with regard to these functions.
- **A DOE foundation can serve to assist lab-associated foundations in scaling-up innovations that emerge from their respective lab.** It can maintain long-term relationships with philanthropies and other funding organizations across the nation and work with lab-associated foundations to develop the level of funds and patient capital needed for the scale-up of new technologies that have high-cost structures and lengthy development cycles. If the DOE foundation were complemented with an endowment of its own, it could use some of the proceeds of this endowment's investments to supplement the efforts of lab-associated foundations to scale-up technologies emerging from their associated lab or labs. As noted in Chapter 2, a DOE foundation could establish a for-profit subsidiary-investment fund that would purchase a minority equity stake in startup and scale-up opportunities.
- **A DOE foundation can help DOE respond rapidly to national needs**. The recent experience of the Foundation for NIH, described in Chapter 2, shows that an agency affiliated foundation can prove to be an agile and responsive means to mobilize skills and resources to address current national exigencies.
- **A DOE foundation can expand DOE's current technology transfer toolkit.** Inducement prize contests are a case in point, where low administrative barriers to entry can attract a diverse range of talent and stimulate interest in the enterprise well beyond the participant pool. The limited historical experience and theoretical literature suggest

that the success of prizes in these respects depends on the choice of targets and design features as well as the administrative competence of the sponsor.[203]

- **The DOE foundation can provide additional flexibility and capabilities, complementing the work of the Office of Technology Transitions.** As a complement to the work of OTT, it can provide a focal point for cooperation with outside stakeholders. For example, it can work with the lab-associated foundations to facilitate innovators' access to DOE's technical expertise and world-class facilities; connect DOE-funded researchers with external partners, funding, and tools; and catalyze, reward, and strengthen collaborations among researchers and private-sector partners to support moving technologies from lab to market.
- **A DOE foundation can assist the extensive technology development and technical assistance activities that are performed through extramural programs**. Such programs include ARPA-E and SBIR, Clean Energy Manufacturing Institutes and other R&D Consortia, as well as closely aligned DOE programs such as Better Buildings.

While the creation of a national foundation offers many potential benefits, the Academy's discussions with DOE stakeholders drew out several areas of potential concern. These issues *need* to be addressed in the enabling legislation for the DOE foundation.

- A DOE foundation should not duplicate or interfere with initiatives run out of lab-associated foundations
- A DOE foundation should not duplicate or interfere with other federal and state-funded programs, initiatives, and activities, regional innovation hubs, technology incubators and accelerators, private foundations, and other philanthropies and trusts
- A DOE foundation should not crowd-out funding for existing lab-associated foundations.
- A DOE foundation should not introduce an additional administrative burden on labs and stewarding program offices.
- Expenditures by the DOE foundation network should not lead to an appropriation reduction by Congress to DOE or by related state governments.
- A DOE foundation should not pose an additional burden on DOE in terms of coordination and related responsibilities. It should operate in coordination with OTT.
- A DOE foundation should avoid conflicting with agency policies in connection with economic, national and research security matters.

Taken together, a network of lab-associated foundations, assisted by a DOE foundation, can reinforce agency missions; provide a flexible and efficient mechanism for establishing public-private R&D partnerships; enable the solicitation, acceptance, and use of private donations to supplement the work performed with federal R&D funds; facilitate the commercialization of

[203] NASEM: *Innovation Inducement Prizes at the National Science Foundation*. Washington D.C: National Academies Press, 2007.

federally funded R&D; further enable federal agencies to attract and retain scientific talent; and enhance public education and awareness regarding the role and value of federal R&D.

**Finding:** A DOE foundation could provide a complementary and supplementary role to the DOE, National Laboratories, and the lab-associated foundations in areas where their missions are aligned.

**Recommendation:** The Panel recommends the creation of a DOE foundation that would be complementary and supplementary to DOE, National Laboratories, and the lab-associated foundations. Further, the Panel recommends the adoption of a "networked approach" that would involve a national level foundation working closely with current and future lab-associated foundations.

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# Appendix B: List of Completed Interviews

(Titles and positions listed are accurate as of the time of the Academy's initial contact)

***Department of Energy***

Conner Prochaska, Chief Commercialization Officer, Office of Technology Transitions
Marcos Gonzales Harsha, Principal Deputy Director, Office of Technology Transitions
Zack Baize, Program Manager, Office of Technology Transitions
Charles Russomanno, Program Manager, Office of Technology Transitions
Clara Asmail, Senior Policy Advisor, Office of Technology Transitions
Elise Atkins, Chief of Staff and Senior Advisor, Office of Technology Transitions
Rochelle Blaustein, Associate General Counsel, Office of General Counsel
Sarah Garman, Acting Strategic Priorities and Impact Analysis Director, Energy Efficiency & Renewable Energy
Bindu Jacob, Deputy Assistant Secretary for Operations, Energy Efficiency & Renewable Energy
Derek Passarelli, Director, Golden Field Office, Energy Efficiency & Renewable Energy
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Alex Fitzsimmons, Deputy Assistant Secretary for Energy Efficiency, Energy Efficiency & Renewable Energy
Mark Gilbertson, Principal Deputy Assistant Secretary, EM & National Lab Operations Board
Kurt Gerdes, Director, Office of Technology Development
Elizabeth Connell, Deputy Assistant Secretary, Office of Regulatory and Policy Affairs, Environmental Management
Benjamin Reinke, Executive Director, OSPP
Allison Bury, Director; Deputy Director of Strategic Planning and Policy, National Lab Operations Board; OSPP
Michael Tadeo, Chief of Staff, Office of Fossil Energy
Steven Winberg, Assistant Secretary, Office of Fossil Energy
Marc Willis, Director of Communications, Office of Fossil Energy
Stephen Walls, Energy Transition Initiative Program Lead, Office of Electricity
Gilbert Bindewald III, Director of Grid Communications and Control, Office of Electricity
Charles Smith, Director, Office of Small and Disadvantaged Business Utilization
Kent Hibben, Senior Policy Analyst, Office of Small and Disadvantaged Business Utilization
Chris Fall, Director, Office of Science
Andrea Yuzon, Senior Advisor, Office of Science
Adam Kinney, Deputy Chief of Staff, Office of Science
Dong Kim, Executive Director, Loan Program Office
Douglas Shultz, Director of Origination Team, Loan Program Office
Valri Lightner, Acting Director, Advanced Manufacturing Office, Energy Efficiency & Renewable Energy
Mike McKittrick, Program Lead for R&D Consortia, Advanced Manufacturing Office, Energy Efficiency & Renewable Energy
Kevin Frost, Director, Office of Indian Energy Policy and Programs
Lizana Pierce, Senior Engineer, Office of Indian Energy Policy and Programs

Manny Oliver, Director, SBIR/STTR Programs Office
Alice Caponiti, Deputy Assistant Secretary for Reactor Fleet and Advanced Reactor Development, Office of Nuclear Energy
Billy Valderrama, Advisor, Office of Nuclear Energy
Kevin Greenaugh, Assistant Deputy Administrator for Strategic Partnership Programs and Science Council Chair, National Nuclear Security Administration
Mark Anderson, Director, Office of Advanced Simulation and Computing and Institutional Research and Development Programs, National Nuclear Security Administration
Lee Finewood, Program Manager for Tritium Irradiation, National Nuclear Security Administration
Jahleel Hudson, Program Manager for Technology Transfer, National Nuclear Security Administration
Anthony Lewis, Program Manager/Engineer, National Nuclear Security Administration

### *Department of Energy National Laboratories*

Julienne Krennrich, Ames Laboratory
Megan Clifford, Argonne National Laboratories
Martin Schoonen, Brookhaven National Laboratory
Cherri Schmidt, Fermi National Laboratory
Jason Stolworthy, Idaho National Laboratory
Todd Pray, Lawrence Berkeley National Laboratory
Russell Carrington, Lawrence Berkeley National Laboratory
Rich Rankin, Lawrence Berkeley National Laboratory
Kathleen McDonald, Los Alamos National Laboratory
Michael Knaggs, National Energy Technology Laboratory
William Farris, National Renewable Energy Laboratory
Michael Paulus, Oak Ridge National Laboratory
Lee Cheatham, Pacific Northwest National Laboratory
Laurie Bagley, Princeton Plasma Physics Laboratory
Mary Monson, Sandia National Laboratory
Renee Steward, Savannah River National Laboratory
Susan Simpkins, SLAC National Accelerator Laboratory
Drew Weisenberger, Thomas Jefferson National Accelerator Facility
Benjamin Silverstein, NGFP Fellow, Pacific Northwest National Laboratory

### *Department of Energy National Laboratory Foundations*

Ivy Clift, President, Berkeley Lab Foundation
Sally Allen, Executive Director, Livermore Lab Foundation
Dona Crawford, Board Member, Livermore Lab Foundation
Jenny Parks, President and CEO, Los Alamos National Lab Foundation

### *Agency Foundations*

Jeff Trandahl, CEO, National Fish and Wildlife Foundation
Lila Helms, Senior Vice President, External Affairs, National Fish and Wildlife Foundation

Will Shafroth, CEO, National Park Foundation
King Laughlin, Senior Vice President, Principal Gifts, National Park Foundation
Chrystal Morris Murphy, Senior Vice President, Community, National Park Foundation
Susan Winckler, CEO, Reagan-Udall Foundation
Lea Ann Browning-McNee, Director of Communications, Reagan-Udall Foundation
Dave Woodbury, Director of Operations, Reagan-Udall Foundation
Kevin Klock, VP of Operations and General Counsel, Foundation for the National Institutes of Health
Sally Rockey, Executive Director, Foundation for Food and Agriculture Research
Pierce Nelson, Vice President for Communications, Centers for Disease Control and Prevention Foundation
Judy Monroe, CEO, Centers for Disease Control and Prevention Foundation
Joseph Caravalho, Jr., M.D., MG, U.S. Army, Ret. CEO, Henry M. Jackson Foundation
Betsy Folk, Executive Vice President and Chief Operating Officer, Henry M. Jackson Foundation
Mark Scher, Director Technology Transfer & Commercialization, Henry M. Jackson Foundation
La Shaun Berrien, Vice President for Research Administration, Henry M. Jackson Foundation
Christina Farias, Director, Foundation for Advanced Education in the Sciences
Georges Benjamin, Chair, Food and Nutrition Committee, Reagan-Udall Foundation
Mary Mitsos, CEO, National Forest Foundation
Cindy Reutzel, Executive Director, Chicago Association for Research and Education in Science Veterans' Affairs Non-Profit Corporation
Kimberly Collins, Director, Veterans' Affairs Nonprofit Program Office
Rick Starrs, CEO, National Association of Veterans' Research and Education Foundation (NAVREF)

### *Congress*

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Johanna Wolfson, Principal, PRIME Impact Fund
Franz Wuerfmannsdobler, Senior Advisor, Bipartisan Policy Center
Paul Zelinksi, Director, FLC & NIST
Stephen Susalka, CEO, AUTM

Chris Karp, Director, Discovery and Translational Sciences, Bill and Melinda Gates Foundation
Robert Kirshner, Chief Program Officer, Science, The Gordon and Betty Moore Foundation
Stephen Brick, Consultant, Spitzer Charitable Trust
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Dan Arvizu, NAPA Fellow, New Mexico State University
Richard Callahan, NAPA Fellow, University of San Francisco
Jennifer Sinsabaugh, CEO, New Mexico Manufacturing Extension Partnership (MEP)
Adam Falk, President, Sloan Foundation
Brook Smith, Director of Public Engagement, Kavli Foundation
Chris Martin, Head of the Office of Science, Kavli Foundation
Ramsay Huntley, Sustainable Finance Strategist, Wells Fargo Foundation
Robert Stoner, Deputy Director for Science and Technology, MIT Energy Initiative
Tomer Inbar, Partner, Patterson Belknap Webb & Tyler LLP
Richard Gomes, Deputy CEO, Shell Foundation

# Appendix C: Study Methodology

This Appendix provides additional information on the report's methodology, including fieldwork.

### Methodological Approach

The study was conducted from May through December 2020 and employed a mixture of qualitative and quantitative research methods, as outlined in the team's research design. The Study Team's research was conducted in several phases, as outlined below.

- ***Phase One: DOE Research: May-June 2020***

  The Study Team sought to acquire a preliminary level of knowledge related to DOE activities, programs, and structures, including those operated by the head office program offices and National Laboratories. This included a review of DOE activities, programs and strategic objectives related to the development and transfer of innovative technologies.

  Further, the team cataloged the activities and performance objectives of the National Laboratories; researched the activities, leading practices, and performance metrics of comparable agency foundations; and began an initial round of semi-structured interviews.

  In addition, the Academy selected six Academy Fellows to serve as the expert panel for the study. Panel members were selected on the basis of their expertise in relevant subject areas. Their biographies appear in Appendix G.

  During this phase, the team completed the following tasks related to the study:

  - Catalog key DOE activities, programs, and structures, including those operated by the head office program offices and National Laboratories.
  - Develop a glossary of terms to ensure consistent usage throughout the study.
  - Describe the range of technologies developed by DOE and the different challenges they face in prototype development, scale-up, and manufacturing.
  - List DOE strategic goals and objectives as it relates to the development and transfer of innovative technologies.
  - List the performance metrics of specific DOE programs and National Laboratories.
  - Catalog the existing innovation tool kit (including SBIR, I-Corp, and ARPA-E) and describe how these are being used in conjunction with each other to further agency and sub-agency missions.
  - Design analysis and criteria for the review of comparable foundations and related performance metrics.

- ***Phase Two: Field Research: July-October 2020***

  Beginning in July, the team commenced its fieldwork in accordance with the project's research design and the three lines of inquiry provided above. The team's fieldwork spanned four months and comprised several different research techniques.

  The following is a brief description of field research activities:

  - **Review of official documents and related literature:**
    The Study Team completed an extensive review of documents including DOE annual reports, policy documents, Strategic Plans, Congressional Budget Justifications; federal policy guidance and reports on technology transfer activities; reports from external stakeholders including CRS, GAO and the Office of Inspector General; House and Senate legislation related to the DOE foundation; related advocacy literature; and relevant academic studies. Appendix A provides a complete list of documents and related literature.

  - **Data Collection**: To better understand the span of DOE's technology transfer activities, including those operated by the program offices and National Laboratories, the team collected and analyzed the performance metrics utilized by those entities and the attendant data for FY 2016-2018.[204] In addition, the team reviewed the Technology Transfer, Commercialization, and Partnerships components of the FY 20 Annual Laboratory Plans of various National Laboratories. In addition to providing a discussion of those activities, the plans articulate the labs' vision, and immediate and future strategies. Finally, the team interviewed head office staff to confirm the team's understanding of the data collected.

  - **Semi-structured Interviews**: The Study Team conducted 115 interviews, including the DOE program offices and internal stakeholders, select agency and non-agency nonprofit foundations, external stakeholders, and subject matter experts. For each interview, the team prepared an interview guide with tailored discussion questions and an overview of the DOE foundation study. Interviewees were advised that their comments were not for attribution. Appendix B provides a full list of interviews and attendees.

    Interview Themes and related questions
    Interviews with DOE program staff and internal stakeholders focused on program mission, research activities, technology transfer activities, current challenges in technology innovation and public-private-partnership activities, and the potential interest in a DOE foundation. Figure C.1 below provides the key themes and related questions addressed during the interviews.

[204] At the time of report writing, FY 2019 data on tech transfer was not available to the Study Team.

**Figure C.1: Interview Themes and Related Questions**

| Theme | Related Questions |
|---|---|
| Program Mission | • How the program office mission relates to the broader DOE mission, including strategic goals and objectives?<br>• Program Office budget; breakout of R&D expenditures<br>• Description of research activities and related TRL levels.<br>• How the program office works with other offices and labs on cross-department initiatives.<br>• How the program office exercises oversight and performance evaluation of its the labs. |
| Program Office Tech Transfer Definition, Activities, and Portfolio | • How the program office defines technology transfer in the context of its mission. What metrics are used to measure performance?<br>• How closely aligned is technology transfer to the mission of the program office?<br>• To what extent does the program office participate in technology transfer innovative programs? What is the program office's role in these programs and the metrics used to measure performance?<br>• Which program initiatives have been successful? What have been some principal challenges? Are there internal structural, or cultural impediments that may contribute to those challenges?<br>• What changes in legislation, regulation, policy, procedures or practices would help advance that goal?<br>• What are the programs in your technology transfer portfolio? |

| Theme | Related Questions |
|---|---|
| Role of an agency-wide foundation | • Has your program office considered the possible role of an agency-level, nonprofit foundation to support its technology transfer activities?<br>• Are their technologies in your portfolio that may be candidates for commercialization?<br>• Potential interest from private-sector and philanthropic foundations to participate in technology transfer activities.<br>• Agency foundations perform various roles to support the mission of the related federal agency. How might an agency-wide foundation work with the program office and its labs to pursue its technology transfer objectives?<br>• Three of the DOE National Laboratories have local foundations. Is your program office considering this option?<br>• What are your views as to whether a national foundation, individual lab foundation or combination thereof might serve the program office mission? |

Interviews with non-DOE entities included agency and non-agency foundations, external stakeholders, and subject matter experts. The Study Team selected interview questions in accordance with the function and interests of the interviewee. Questions addressed various themes, including how an agency foundation can support the mission of a federal agency; identifying the essential attributes for future success of an agency foundation; potential interest in collaborating with a DOE foundation to pursue program goals. Figure C.2 below provides the key themes and related questions addressed during the interviews.

**Figure C.2: Interview Themes and Related Questions Continued**

| Theme | Related Questions |
|---|---|
| Foundation support for a federal agency | • What are the various roles an agency foundation can perform to support the broader mission of a federal department/agency? |

| Theme | Related Questions |
|---|---|
| | • What is the process to determine foundation a foundation's activities? How are these determined? |
| Essential attributes of an agency foundation | • What are the requisite structural characteristics and attributes of a successful foundation? |
| Governance | • How does an agency foundation strike a successful balance of independence and support for an agency?<br>• How does management define good governance? What are the key attributes? |
| Technology transfer including commercialization of innovative technologies. | • How do comparable foundations engage with the private sector and industry to support the research and development, and commercial application of emerging technologies?<br>• What is the potential interest among private-sector and Philanthropic entities to work with a DOE foundation to pursue program goals?<br>• Are there specific DOE technologies and technology transfer activities of interest to the external donor community? What are the modalities used by these external entities? |

### 1. Survey of the 17 National Laboratories

The team administered a survey of the 17 the labs. The survey provided a vehicle to initially engage with the labs on technology transfer and informed the discussion framework of the focus group sessions which followed. A copy of the survey can be found in Appendix D. Figure D.1 below provides the key themes and related questions addressed in the survey.

# Appendix D: Lab Survey Questions

**Figure D.1: Lab Survey Questionnaire: Themes and related questions**

| Theme | Related Questions |
|---|---|
| Importance of Tech Transfer to the mission of the Lab | 1. How closely aligned is technology transfer to the mission of your lab? (range 1-5)<br>2. What have been some principal challenges? |
| Characteristics of the Tech Transfer Portfolio | 3. What are the programs in your technology transfer portfolio?<br>4. In the research /development /prototype /commercialization spectrum, what parts do your programs occupy?<br>5. Are there any gaps in this portfolio?<br>6. What role could a foundation play to round out this portfolio? |
| TT Evaluation | 7. How does your lab evaluate the success of your TT programs--individually, and as a portfolio?<br>8. What does the PEMP measure regarding tech transfer? |
| Ecosystem | 9. How do lab TT programs cooperate with university-based incubators, accelerators, etc.?<br>10. What role could a foundation play in linking the lab to universities and industries in the region? |
| Scale Up | 11. Once start-up companies graduate from your programs, what major challenges do they face in scaling up?<br>12. What supporting role can a foundation play in assisting the scale-up of lab start-ups? |

- ***Focus Groups:***

  Building on the data collected from the Lab questionnaires, the Academy conducted a series of virtual focus groups with the 17 National Laboratories. The purpose of the focus groups was twofold:

- to engage in a dialogue on tech transfer activities including the current state, future strategy and potential obstacles; and
- to solicit feedback on how a DOE agency foundation might add value in the context of the lab's tech transfer activities.

As indicated in figure D.2 below, the labs were divided into six groups according to the DOE program sponsor and type of research conducted at the labs. Attendees were drawn from the tech transfer staff at each laboratory. Figure D.3 lists the principal themes and sub-themes discussed with the focus groups.

**Figure D.2: Lab Focus Group Sessions**

| Name | Branch | Focus Group | Date Interviewed |
|---|---|---|---|
| Lawrence Berkeley National Laboratory | Office of Science | A | 9/14/2020 |
| Oak Ridge National Laboratory | Office of Science | A | 9/14/2020 |
| Argonne National Laboratory | Office of Science | A | 9/14/2020 |
| Pacific Northwest National Laboratory | Office of Science | A | 9/14/2020 |
| National Energy Technology Laboratory | Office of Fossil Energy | B | 9/11/2020 |
| Princeton Plasma Physics Laboratory | Office of Science | C | 9/16/2020 |
| SLAC National Accelerator Laboratory | Office of Science | C | 9/16/2020 |
| Fermi National Accelerator Laboratory | Office of Science | C | 9/16/2020 |
| Thomas Jefferson National Accelerator Facility | Office of Science | C | 9/16/2020 |

| Name | Branch | Focus Group | Date Interviewed |
| --- | --- | --- | --- |
| National Renewable Energy Laboratory | Office of Energy Efficiency and Renewable Energy | D | 9/15/2020 |
| Savannah River National Laboratory | Office of Environmental Management | D | 9/15/2020 |
| Idaho National Laboratory | Office of Nuclear Energy | D | 9/15/2020 |
| Los Alamos National Laboratory | National Nuclear Security Administration | F | 9/21/2020 |
| Sandia National Laboratories | National Nuclear Security Administration | F | 9/21/2020 |
| Lawrence Livermore National Laboratory | National Nuclear Security Administration | F | 9/21/2020 |
| Ames Laboratory | Office of Science | C | 9/25/2020 |

**Figure D.3: Current State and Challenges**

| Theme | Related sub-themes |
| --- | --- |
| Unique Features of the individual Lab | • Contractual relationship with DOE<br>• Scale of Lab—single focus, multiple missions<br>• Nature of Lab work—TRL level, intensity of collaboration<br>• Characteristics of technology—scale, high security |
| Incentives and Innovation Mechanisms | • Innovation partnership programs<br>• Career reward mechanisms<br>• Metrics, missing information, and feedback |
| Institutional Constraints | • Institutional Constraints<br>• Budget mechanisms; funding sources<br>• Reporting requirements— PEMP<br>• Metrics and feedback |

**Figure D.4 Future State and Potential Barriers**

| Theme | Related sub-themes |
|---|---|
| Desired Future state | • What is your Lab's long-term strategic outlook?<br>• How is your Lab adapting to new realities and emerging needs? E.g., foreign engagements, digital IP<br>• What happens to research after it transitions from your Lab? How is it tracked? Intermediaries? |
| Key barriers to progress | • Issues related to Lab structures, missions<br>• Issues related to state and federal public policy<br>• Issues related to availability of external financing<br>• Issues related to manufacturing infrastructure<br>• Issues related to the expert and skilled workforce<br>• Issues related to metrics, feedback, incentives<br>• Issues related to responsiveness and flexibility |
| What roles can a DOE foundation play in the context of your lab? | • Supplement incentives within lab? E.g., rewards or prizes for innovation work<br>• Supplement financing of scale up activities?<br>• Develop specialized analyses to inform policymaking?<br>• Creating bridges to regional economic development?<br>• Promoting thought leadership and analysis? |
| What are the key challenges to setting up a foundation? | • Authority?<br>• Funding?<br>• Program areas?<br>• Integration with DOE programs? |

# Appendix E: DOE Technology Transfer Initiative Summaries

DOE has developed and implemented a number of programs, initiatives, and mechanisms to facilitate the transfer of innovative technologies from its the labs to commercial markets. Generally, these initiatives and programs are executed at the laboratory level and employ a broad array of approaches toward achieving the Department's goals in the realm of technology transfer. Specifically, DOE's suite of technology transfer initiatives:[205]

- Encourage public-private partnerships and leverage private dollars in key stages of the technology maturation cycle;
- Pair National Laboratory expertise, capabilities, and facilities with external partners;
- Increase awareness and accessibility of National Laboratory expertise, capabilities, and capabilities;
- Provide entrepreneurial training to promising inventors at the labs;
- Facilitate high-risk, high-return research projects through the DARPA model at the Advanced Research Projects Agency – Energy;
- Improve advanced materials and infrastructure;
- Assist small businesses with technical needs, and incentivize small businesses to develop new technologies; and
- Streamline contracting and partnership processes with external stakeholders.

Some of these programs and initiatives are DOE-piloted. Though, some, like the Technology Commercialization Fund, are created or congressionally authorized in federal legislation. The list below refers to twelve such initiatives and programs summarized by the Academy, though more than another 100 exist within DOE and the labs:

1. Technology Commercialization Fund (TCF)

[205] United States Congress, *Energy Policy Act of 2005*. https://www.congress.gov/109/plaws/publ58/PLAW-109publ58.pdf; U.S. Department of Energy Office of Technology Transitions, *Technology Commercialization Fund*. https://www.energy.gov/technologytransitions/initiatives/technology-commercialization-fund; U.S. Department of Energy Office of Technology Transitions, *Lab-Embedded Entrepreneurship Programs*. https://www.energy.gov/eere/amo/lab-embedded-entrepreneurship-programs; U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, *AMO LEEP Overview 2019*.; U.S. Department of Energy Office of Technology Transitions, *Energy I-Corps*. https://www.energy.gov/technologytransitions/energy-i-corps; U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, *Technologist in Residence Program*. https://www.energy.gov/eere/amo/technologist-residence-program; U.S. Department of Energy Office of Technology Transitions, *Report on the Utilization of Federal Technology: Fiscal Years 2016 and 2017*.; U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, *Small Business Vouchers*. https://www.energy.gov/eere/technology-to-market/small-business-vouchers; U.S. Department of Energy, Order 481.1D: *Strategic Partnership Projects*. https://www.directives.doe.gov/directives-documents/400-series/0481.1-BOrder-d/@@images/file; U.S. Department of Energy Office of Technology Transitions, *Lab Partnering Service*. https://labpartnering.org/; U.S. Department of Energy Office of Science, *Small Business Innovation Research and Small Business Technology Transfer*. https://www.energy.gov/science/sbir/small-business-innovation-research-and-small-business-technology-transfer; U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, *Manufacturing Demonstration Facility (MDF) at oak Ridge National Laboratory*. https://www.energy.gov/eere/amo/manufacturing-demonstration-facility-mdf-oak-ridge-national-laboratory

2. Lab Embedded Entrepreneurship Programs
3. Energy I-Corps
4. Technologists in Residence (TIR)
5. Small Business Vouchers (SBV) Program
6. Strategic Partnership Projects (SPPs)
7. Agreement for Commercializing Technology
8. Lab Partnering Service
9. Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR)
10. Manufacturing Demonstration Facility (MDF)

A key facet of this report is to examine how a potential DOE, agency-related foundation would work best in tandem with DOE's existing network of innovative initiatives.

**Technology Commercialization Fund (TCF)**

Mandated in the Energy Policy Act of 2005, TCF is a program that provides funds to the National Laboratories to promote promising energy technologies for commercial purposes.[206] Its goals are to increase the number of these technologies developed at the labs that graduate to commercial development, and to enhance DOE's technology transitions system with a competitive approach to lab-industry partnerships. The TCF is funded by nine-tenths of one percent of the appropriations made available to DOE for applied energy research, development, demonstration, and commercial application for each fiscal year, amount to about $30 million each year.[207] The authorizing legislation called for the TCF to use this budgetary resource to match contributions from private partners.

The Technology Commercialization Fund provides for applicants to propose projects under one of two topic areas per project.[208] Topic 1: "technology maturation" projects range from 6-18 months and do not require a partner. Topic 2: "technology commercialization" projects range from 12-36 months and require a partner in the private sector. Topic 2 projects typically take the form of a CRADA, although this is not an absolute requirement for the labs. In FY 2017, DOE estimated that Topic 1 projects would receive between $100,000-$150,000 per award, and Topic 2 projects between $250,000-$750,000 per award. Applicants were able to identify up to three DOE Program or Technology Offices per proposal from which a single award up to the above-mentioned amount may be appropriate.

The entire process for selection is comprised of letters of intent, proposals, independent merit reviews by two technical SMEs, and one commercialization expert. Senior DOE Officials then

[206] United States Congress, *Energy Policy Act of 2005*. https://www.congress.gov/109/plaws/publ58/PLAW-109publ58.pdf
[207] U.S. Department of Energy Office of Technology Transitions, *Technology Commercialization Fund*. https://www.energy.gov/technologytransitions/initiatives/technology-commercialization-fund
[208] Research Into Action, Inc., *First Interim TCF Outcomes Report*. https://www.energy.gov/sites/prod/files/2020/07/f76/First%20Interim%20TCF%20Outcomes%20Report%20Final%2002.28.19.pdf

make recommendations on the merit review committee and make selection decisions. Selections are made based on the following criteria, which make up an overall merit score:

1. Commercialization Evaluation (35 percent of composite score)
2. Technical Merit Evaluation (65 percent of composite score)
    a. Criterion 1: Technology Maturity (40 percent)
    b. Criterion 2: Project Plan (40 percent)
    c. Criterion 3: Project Team and Resources (20 percent)

The first outcomes report found that awarded principal investigators (PIs) were making positive progress toward commercializing their technologies.[209] The TRLs of the technologies of awarded PIs had advanced significantly over non-TCF PI technologies. About 50 percent of TCF technologies advanced in TRL, compared to 10-15 percent of TRL advancement in non-TCF technologies, at the time of the study. Findings also indicated that TCF technologies prompted significantly higher industry interest. More than half of awarded PIs reported that industry interest in their technologies increased to a "large extent" or "very large extent" compared to one-quarter of non-awarded PIs. Awarded PIs more frequently reported more customer discovery activities and knowledge on how to bring their technologies to scale. Awarded PIs also more frequently reported presenting their technologies in conferences and workshops and applying for patents.

The "Second Interim TCF Outcomes Report" (2020) examined the same four categories of outcomes and impacts.[210] The study findings were the same as in the first report, with one notable difference: a greater proportion of awarded PIs reported follow-on funding than non-awarded PIs. They also had a larger funding amount, on average, and a greater proportion of their follow-up funding came from the private sector or governmental end-users. The study found that about 75 percent of awarded PI technologies increased in TRL, compared to about 25 percent of PIs.

**Figure E.1: DOE's TCF – Participating National Laboratories**

| ***2016-2020*** | **CRADAs** | **Funding** |
|---|---|---|
| **Total** | **324** | **$94,121,135** |
| ***Office of Science*** | | |
| **Ames** | 3 | $725,000 |
| **Argonne** | 37 | $13,492,685 |

[209] *Ibid*
[210] Opinion Dynamics, *Second DOE Interim TCF Outcomes Report.* https://www.energy.gov/sites/prod/files/2020/07/f76/Second%20Interim%20TCF%20Outcomes%20Report_FINAL_2020-06-18.pdf

| *2016-2020* | CRADAs | Funding |
| --- | --- | --- |
| **Brookhaven** | 5 | $860,625 |
| ***Nuclear Energy*** | | |
| **Idaho** | 37 | $8,964,920 |
| ***NNSA*** | | |
| **Lawrence Berkeley** | 9 | $1,923,831 |
| **Lawrence Livermore** | 18 | $6,640,031 |
| **Los Alamos** | 5 | $2,500,000 |
| ***Fossil Energy*** | | |
| **NETL** | 10 | $3,607,514 |
| ***EERE*** | | |
| **NREL** | 52 | $15,867,133 |
| **Oak Ridge** | 56 | $23,601,990 |
| **PNNL** | 33 | $7,985,000 |
| **Sandia** | 58 | $7,802,406 |
| **SLAC** | 1 | $150,000 |

(Figure E.1 created by the National Academy of Public Administration)

**Lab-Embedded Entrepreneurship Programs**

The Advanced Manufacturing Office's (AMO) Lab-Embedded Entrepreneurship Program is a DOE program piloted to pair "top entrepreneurial scientists and engineers and embed them within [DOE the labs] to perform early-stage research and development that may lead to the launch of energy or manufacturing businesses in the future."[211] The Lab Embedded Entrepreneurship Program began in 2014 at Lawrence Berkeley National Laboratory with a project named "Cyclotron Road." Since that time, in 2016, the projects "Innovation Crossroads"

[211] U.S. Department of Energy Office of Technology Transitions, *Lab-Embedded Entrepreneurship Programs*. https://www.energy.gov/eere/amo/lab-embedded-entrepreneurship-programs

and "Chain Reaction Innovation" launched at Oak Ridge and Argonne National Laboratories, respectively. Each lab has a partner organization, which helps to manage the program, with varying degrees of engagement. Each project entails a non-profit partner organization, which funds the fellows through a grant from DOE. Currently, the program costs about $7.5 million per year for 15 fellows (five at each lab).

The Lab Embedded Entrepreneurship Program  is implemented in three common key stages:

1. Recruit the best energy technology innovators
2. Leverage expert mentorship and world-class facilities at the labs
3. Position people and technology for market

The program selects potential innovators from a pool of early to mid-career researchers on both an intra- and extramural basis. Entrepreneurial fellows are selected by an advisory panel composed of three program directors, an AMO representative, other interested DOE offices, and investors. The proposals are subjected to a down-selection process, and a pitch meeting to the advisory panel. The deciding official is the AMO representative. After selection, entrepreneurial fellows are to participate in a project that provides:[212]

- A CRADA with one of the three participating National Laboratories;
- A stipend of $90,000-100,000 on an annual basis;
- Payments of overhead for the lead laboratory; and
- 1-on-1 mentorship, education, and corporate and professional development

At the conclusion of a given project's first year, AMO may decide to continue or terminate the project. The major criterion for success is follow-on funding.

**Energy I-Corps**

DOE's Energy I-Corps is modeled after the National Science Foundation's Innovation Corps.[213] It was launched in August of 2014 as a pilot out of DOE's Office of Energy Efficiency and Renewable Energy, providing $2.3 million for FY 2015.[214] Energy I-Corps selects teams of lab researchers to participate in a training that guides them in developing and testing business models for their technologies by conducting research with relevant market actors. All training teams are composed of at least three members, the research team's principal investigator (always a National Lab employee), the entrepreneurial lead, and an industry mentor. By November 2017, Energy I-Corps had, had trained six cohorts of research teams, with plans to launch a seventh in April 2018.[215]

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[212] U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, *AMO LEEP Overview 2019*.
[213] U.S. Department of Energy Office of Technology Transitions, *Energy I-Corps*. https://www.energy.gov/technologytransitions/energy-i-corps
[214] Research Into Action, Inc., *Energy I-Corps Program: Year 1 Process and Impact Evaluation*. https://www.energy.gov/sites/prod/files/2018/02/f49/energy_i-corps_program_year_1_process_and_impact_evaluation_0.pdf
[215] Research Into Action, Inc., *Energy I-Corps Program: 2017 Case Studies*.

Between fall of 2015 and fall of 2017, seventy-one technology teams from ten the labs had participated in the six trainings.[216]

The program is typically conducted over two months per cohort. Team members are guided through a discovery process with contacts in their target market, including potential customers, supply chain actors, and partners. During the process, team members discuss with market actors: customer pain points, interest in the innovation, likely costs, and possible revenue. After training, researchers return to the lab with a framework for industry engagement to guide future research and inform a culture of market awareness within the labs.

A first-year evaluation of the program found that the pilot was successful and was effectively building on the lessons learned by the participating labs and instructors to improve future training. The second-year evaluation of the program found that the business training it provided was essential to participating team's commercialization progress and that follow-on funding is important to technology readiness level advancement.

**Technologists in Residence**

DOE's TIR program involves the competitive selection of pairings between a technologist from a National Laboratory, a senior technical staff member, a consortium of companies, or a state or regional economic development entity.[217] It is an EERE Advanced Manufacturing Office initiative created to strengthen America's competitiveness in research and development, and targets early stage TRL levels.[218] "In FY 2016, EERE dedicated $2 million to fund six competitively selected lab-industry pairs (No additional funds were dedicated in FY 2017)."

Each technologist may represent single or multiple National Laboratories or companies. Pares of technologists work together for a period of 18 to 24 months to:

1. Identify the participating company's technical priorities and challenges, and the capabilities across the labs that may be suitable to address them.
2. Propose collaborative efforts to develop science-based solutions for the company's most strategic issues.
3. Develop general agreement and scope of work for proposed collaborative R&D efforts. The proposed R&D does not use TIR program funds.

Eligible applicants are National Laboratories that identify an internal technologist and industry partner who may represent a company of consortium. Proposed partnerships are evaluated on criteria, including technical focus, proposed approach and work plan, and team competency and resources. Evaluations are also based on the degree to which proposals demonstrate additionality in terms of both partnerships and unexplored focus areas.

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[216] National Laboratories that participated in the Energy I-Corps program by 2017 included: Argonne, Fermi, Idaho, Lawrence Berkeley, Lawrence Livermore, Los Alamos, National Renewable Energy Laboratory, Oak Ridge, Pacific Northwest, and Sandia.
[217] U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, *Technologist in Residence Program*. https://www.energy.gov/eere/amo/technologist-residence-program
[218] U.S. Department of Energy Office of Technology Transitions, *Report on the Utilization of Federal Technology: Fiscal Years 2016 and 2017*.

**Figure E.2 TIR-Funded Pairs to Date**

| | |
|---|---|
| **Argonne** | 7 |
| **Brookhaven** | 1 |
| **Idaho** | 1 |
| **Lawrence Berkeley** | 1 |
| **Los Alamos** | 1 |
| **NREL** | 1 |
| **Oak Ridge** | 2 |

(Figure E.2 created by the National Academy of Public Administration)

**Small Business Vouchers Program**

DOE's SBV program was launched in March 2015 with four goals:[219]

1. Increase engagement between the DOE National Laboratories and small businesses with high growth potential
2. Increase Lab awareness of small business technology development and technical needs
3. Encourage Labs to assist with the commercialization of potential technologies across a wide spectrum of applications
4. Enhance U.S. economic competitiveness

A key objective of the program was to reduce the amount of time required for small businesses to partner with the DOE the labs. The original authorizing legislation includes a cost-sharing requirement between the Department and private sector participants.

SBV provides small businesses operating in the clean energy market with access to the DOE National Laboratories by simplifying its contracting processes, making that practice more transparent, and increasing the affordability of lab facilities. The initiative also affords selected businesses advantages in the global marketplace and familiarizes the National Lab complex with the challenges small business face in the energy sector. A key feature of SBV is connecting small businesses to world class resources and capabilities at the national lab facilities, including high performance computing, intermediate scaling to generate samples for potential customers, and

[219] U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, *Small Business Vouchers*. https://www.energy.gov/eere/technology-to-market/small-business-vouchers; Research Into Action, *Evaluation of U.S. DOE Small Business Vouchers Pilot*. https://www.energy.gov/sites/prod/files/2018/12/f58/eval-small-business-vouchers-pilot-112718.pdf

the opportunity to validate the performance of technologies. As of 2018, DOE had conducted three rounds of the program.

In 2018, an external evaluation of the first three rounds was conducted. The evaluation found that DOE had engaged with over 1,200 small businesses through the program. Through SBV, 14 of the DOE labs contracted with 114 small businesses, providing them with $22 million worth of assistance. 91 percent of awardees rated positively the time it took to contract with DOE. 81 percent participants advanced their technologies at least one level on the technology readiness level (TRL) scale, compared with 43 percent of non-participants. 47 percent of awardees reported follow-on funding for their technologies, compared with 18 percent of non-awardees. 72 percent of participants also reported knowledge gain, and 43 percent reported they gained skill as a result of engaging in the SBV program.

## Strategic Partnership Projects

SPPs, formerly known as work for others, involve work performed for entities outside of DOE, by DOE. Work in this category is may be performed by DOE National Laboratory personnel, excluding the National Energy Technology Laboratory, and their respective contractor personnel. The SPP program lists the following objectives, by directive:[220]

- Provide assistance to Federal agencies and non-Federal entities in accomplishing goals that may be otherwise unattainable and to avoid duplication of effort at Federal facilities.
- Provide access to DOE/NNSA highly specialized or unique facilities, services, or technical expertise to non-DOE/non-NNSA entities when private sector facilities are inadequate.
- Increase research and development interactions between DOE/NNSA facilities and industry to provide opportunities for transferring technology originating at DOE/NNSA facilities to industry for further development or commercialization.
- Assist in maintaining core competencies and enhancing the science and technology base at DOE/NNSA facilities.

In FY 2017, DOE's SPPs program consisted of 2,047 active SPPs, 403 active SPPs with small business involvement, and 312 small businesses involved in active SPPs.[221]

## Agreement for Commercializing Technology

The ACT is a DOE piloted mechanism, launched in 2012, to complement existing technology transfer mechanisms available to the National Laboratories.[222] The ACT provides DOE laboratory M&O contractors with flexibility in modifying certain terms and conditions in traditional agreements such as CRADAs and SPPs. Through this mechanism, M&O contractors are allowed to enter into agreements with sponsors in the private and non-Federal public sectors. Between fiscal years 2012 and 2017, four of the labs participated in the pilot mechanism: Pacific Northwest

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[220] U.S. Department of Energy, Order 481.1D: *Strategic Partnership Projects*. https://www.directives.doe.gov/directives-documents/400-series/0481.1-BOrder-d/@@images/file
[221] U.S. Department of Energy Office of Technology Transitions, *Report on the Utilization of Federal Technology: Fiscal Years 2016 and 2017*.
[222] *Ibid*.

National Laboratory, Lawrence Livermore National Laboratory, National Renewable Energy Laboratory, and Brookhaven National Laboratory. Activity in these fiscal years yielded 104 agreements. In FY 2017, DOE reported 98 active ACTs, 4 active ACTs with small business involvement, and 4 small businesses involved in active ACTs.

## Lab Partnering Service

The Lab Partnering Service is a DOE initiative that uses the website labpartnering.org to "bring together patents, intellectual property, and expertise from across the [DOE National Laboratories]."[223] The website is used as a tool to amplify activities and capabilities at the labs to better attract private sector partners to the labs. In a press release in July of 2018, DOE announced the launch of LPS, and listed its three constituent components:[224]

1. Connect with Experts: Unprecedented access to top national lab researchers will allow investors and innovators to connect with relevant subject matter experts and receive unbiased and non-competitive technical assessments.
2. Technical/Marketing Summaries: Direct access to pre-validated, ready to license, and commercialize technologies.
3. Visual Patent Search: Dynamic online search and visualization database tool for patents associated with DOE National Laboratories.

LPS' database is comprised of 21 DOE facilities, over 1,400 technologies, and more than 250 experts at the National Laboratories accessible to the public.[225] It shows a selection of the number of experts, facilitates, technologies, success stories, and patents by lab. This selection is curated to include research leaders that are in a position to provide expertise. Members of the public may use LPS to ask questions of experts, explore technologies, and learn how to partner with the National Laboratories through mechanisms including, but not limited to, SPPs, CRADAs, and technical assistance. For the FY 2020 cycle, OTT is placing an increased emphasis on amplifying the Technology Commercialization Fund, posting the TCF Notice of Intent and Solicitation on its website.[226]

## SBIR/STTR

The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) are U.S. Government programs with the intent of assisting select small business to conduct research and development.[227] Congress first authorized SBIR in 1982 to support small firms, and as of 2017, federal agencies must allocate 3.2 percent of their extramural R&D budgets to the program, with no required cost share component.[228] At DOE, funding takes the form of grants

[223] U.S. Department of Energy Office of Technology Transitions, *Lab Partnering Service*. https://labpartnering.org/
[224] U.S. Department of Energy Office of Technology Transitions, *DOE Launches New Lab Partnering Service*. https://www.energy.gov/articles/doe-launches-new-lab-partnering-service
[225] Federal Laboratory Consortium for Technology Transfer, *The DOE Laboratory Partnering Service Webinar*. https://federallabs.org/events/the-doe-laboratory-partnering-service
[226] U.S. Department of Energy Office of Technology Transitions, *OTT Turns 5*. https://www.energy.gov/technologytransitions/articles/ott-turns-5
[227] U.S. Department of Energy Office of Science, *Small Business Innovation Research and Small Business Technology Transfer*. https://www.energy.gov/science/sbir/small-business-innovation-research-and-small-business-technology-transfer
[228] Howell, *Analysis of the U.S. Department of Energy's Energy Efficiency & Renewable Energy and Fossil Energy SBIR Programs*.

and is administered by the SBIR/STTR Programs Office, which works with 13 program offices in the Department. Research topics for SBIR and STTR are developed by DOE technical program managers. The program's over 60 topics cover the broad scope of DOE's multi-faceted mission. It is open to American-owned small businesses with fewer than 500 employees.

Applicant firms must propose projects which fit within the scope of specific SBIR competitions and are subject to evaluation by program managers according to three criteria:

1. Strength of the scientific/technical approach
2. Ability to competently carry out the project; and
3. Impact.

The criteria are used to rank order applications within each competition by DOE technical program managers, and final selections are made by the SBIR/STTR Programs Office based on available funding.

According to a study performed by the National Academies of Sciences, Engineering, and Medicine in 2020, "Since 2000, the DOE SBIR program has awarded roughly $2.45 billion to 2,064 firms. This comprises approximately 5,6000 Phase I awards ($580 million) and 2,400 Phase II awards ($1.87 billion)."[229] Between FY 2013-2017, the top awarded states were California, Massachusetts, Colorado, Ohio, New York, Illinois, Virginia, Texas, and Michigan. In rural states with National Laboratories, DOE SBIR/STTR awards were:

**Figure E.3 DOE SBIR/STTR Awards**

| | |
|---|---|
| Washington | 58 |
| New Mexico | 44 |
| Tennessee | 20 |
| South Carolina | 0 |
| Idaho | 0 |

(Figure E.3 created by the National Academy of Public Administration)

From FY 1989-2014, DOE provided 1,310 SBIR/STTR awards to firms owned by women and socially and economically disadvantaged groups.[230]

A study performed on the SBIR programs of EERE and FE in 2019 found that Phase 1 grants had large, positive effects on firm innovation, growth, and average wages. More specifically, firms that received Phase 1 grants resulted in 250 percent more patents when compared with non-

[229] The National Academies of Sciences, Engineering, and Medicine. https://www.nap.edu/download/25674#
[230] *Ibid*, page 127.

applicants, and lead firms to have 19 percent more employees relative to the year of application than they would have had otherwise.[231]

NASEM's 2020 study of all DOE program offices that participate in SBIR/STTR found that:[232]

1. DOE's SBIR/STTR programs stimulate technological innovation and contribute to DOE R&D needs.
2. Awardees perform technical research usually distant from commercialization but closely connected to DOE R&D needs.
3. DOE's SBIR/STTR programs enable a measurable level of innovation that creates formal intellectual property by private-sector innovators.
4. A small number of SBIR/STTR awardees ultimately achieve significant employment growth. There was no evidence of a statistically significant difference in employment growth between DOE SBIR/STTR-awarded firms and non-awarded firms.

**Manufacturing Demonstration Facility**

The Manufacturing Demonstration Facility (MDF), established in 2012, located at ORNL, is the Department of Energy's designated user facility focused on performing early-stage research and development to improve the energy and material efficiency, productivity, and competitiveness of American manufacturers. The Manufacturing Demonstration Facility is DOE's only designated user facility focused on advanced manufacturing research and development.[233] Initially capitalized with funding from AMO, ORNL, and costs sharing, MDF's FY2020 enacted budget is $20 million. The MDF is located "outside the fence" and utilizes a "Short Form" CRADA document to facilitate rapid engagement with industry.

ORNL works with more than 100 companies yearly for technology advancement and commercialization. More than 20 start-ups have been formed based on ORNL-developed technologies over the past five years. Under the MDF Technology Collaborations Program, industry can leverage world-leading capabilities and expertise in short-term collaborative projects approved by DOE. Academia, National Laboratories, government agencies, and non-governmental organizations may also access the facility through a variety of user and collaborative agreements.

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[231] Howell, *Analysis of the U.S. Department of Energy's Energy Efficiency & Renewable Energy and Fossil Energy SBIR Programs*.
[232] The National Academies of Sciences, Engineering, and Medicine. https://www.nap.edu/download/25674#
[233] U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, *Manufacturing Demonstration Facility (MDF) at oak Ridge National Laboratory*. https://www.energy.gov/eere/amo/manufacturing-demonstration-facility-mdf-oak-ridge-national-laboratory

# Appendix F: Agency Foundation Descriptions

(Descriptions of foundations are gathered from publicly available information on websites and in reports. This reflects how these foundations describe their own missions and is not meant to be an assessment from the National Academy of Public Administration.)

**Centers for Disease Control Foundation (CDCF)**

CDCF helps CDC do more, faster, by forging effective partnerships between CDC and others to fight threats to health and safety. The foundation was established in 1992 to improve the health and safety of all people by substantially enhancing the impact of CDC. It is an independent 501(c)3, and the sole entity created by Congress to mobilize philanthropic and private-sector resources to support CDC. By aligning diverse interests and resources and leveraging all parties' strengths, its focused collaborations with private and philanthropic partners help create a greater impact than any one entity can alone. CDCF helps CDC launch new programs, expand existing programs that show promise, and establish pilot projects to determine whether certain health programs should be scaled up—none of which would be possible without external support that complements government investments. Official website: https://www.cdcfoundation.org/

**Foundation for Food and Agriculture Research (FFAR)**

FFAR builds unique partnerships to support innovative science addressing today's food and agriculture challenges. The foundation was established in 2014. It envisions a world in which every innovating and collaborative science provides every person access to affordable, nutritious food grown on thriving farms. It engages stakeholders across academia, the public sector, and private companies to identify pressing research ideas. It issues requests for applications, conducts prizes, and funds individual scientists and consortia. While an independent 501(c)3, FFAR complements and advances USDA's mission and builds programs that are of mutual interest to USDA and the agricultural community at large. Official website: https://foundationfar.org/

**Foundation for the National Institutes of Health (FNIH)**

FNIH creates and leads alliances and public-private partnerships that advance breakthrough biomedical discoveries, thereby improving the quality of people's lives. The foundation was authorized in 1990, and its purpose was broadened in 1993. FNIH organizes and administers research programs; supports education and training of new researchers; organizes educational events and symposia; and administers a series of funds supporting a wide range of health challenges. As an independent 501(c)3, it raises private funds and creates public-private partnerships to support NIH's mission of making important discoveries that improve health and save lives. Official website: https://fnih.org/

**Foundation for Advanced Education in the Sciences Inc. (FAES)**

The Foundation for Advanced Education in the Sciences is a 501 (c)(3) non-profit organization, located in the National Institutes of Health, which conducts advanced educational programs and supporting activities to promote the productivity and attractiveness of professional life on the NIH campuses. FAES programs complement the work of NIH in accomplishing its mission of research and training in the biomedical sciences. Official website: https://faes.org/

**Henry M. Jackson Foundation for the Advancement of Military Medicine (HJF)**

HJF is a 501(c)(3) organization dedicated to advancing military medicine. It serves military, medical, academic, and government clients by administering, managing, and supporting preeminent scientific programs that benefit members of the armed forces and civilians alike. Since its founding in 1983, HJF has served as a vital link between the military medical community and its federal and private partners. HJF's support and administrative capabilities allow military medical researchers and clinicians to maintain their scientific focus and accomplish their research goals. HJF has grown to a global organization supporting more than 700 national and international research grants, contracts, and cooperative agreements. Official website: https://www.hjf.org/

**National Association of Veterans' Research and Education Foundations (NAVREF)**

Formed in 1992, NAVREF is the 501(c)(3) nonprofit membership organization of research and education foundations affiliated with Department of Veterans Affairs (VA) medical centers but is not authorized by Congress. These nonprofits, also known as the VA-affiliated nonprofit research and education corporations (NPCs), are authorized by Congress to provide flexible funding mechanisms for the conduct of research and education at VA facilities nationwide. VA NPCs were first established in 1988 to provide a flexible funding mechanism. In 1999, Congress broadened the NPCs authority to include educational and training activities. NAVREF helps bring more high-quality clinical trials to veterans faster; provides operational best practices to NPCs; conducts educational and research topic specific convenings; advocates on behalf of NPCs with Congress; and runs an affinity program to reduce costs of products and services for its members. Official website: https://www.navref.org/

**National Fish and Wildlife Foundation (NFWF)**

The National Fish and Wildlife Foundation (NFWF) is dedicated to sustaining, restoring, and enhancing the nation's fish, wildlife, plants, and habitats for current and future generations. NFWF builds partnerships between leading U.S. corporations and federal agencies, nonprofits, and individuals who drive conservation efforts across the United States. It leverages public funds to raise private dollars and award those funds to projects that will do the best across a wide range of landscapes. Since its founding by Congress in 1984, NFWF has supported more than 17,250 projects and enhanced wildlife populations and natural habitats in all 50 states and U.S. territories. With its partners, it protects and restores imperiled species, promotes healthy oceans and estuaries, improves working landscapes for wildlife, advances sustainable fisheries, and conserves water for wildlife and people. Official website: https://www.nfwf.org/

**National Forest Foundation (NFF)**

The mission of the National Forest Foundation is to engage Americans in promoting the health and public enjoyment of our National Forests. NFF works with the U.S. Forest Service and partners to leverage the best thinking, conservation capacity, and community action to measurably improve the health of National Forests and Grasslands. Chartered by Congress as a 501(c)3 in 1990, NFF engages Americans in community-based and national programs that promote the health and public enjoyment of the 193-million-acre National Forest System and administers private gifts of funds and land for the benefit of the National Forests. The foundation conducts on-the-ground conservation activities through grant programs that align with specific strategic initiatives across five regions of the country. Official website: https://www.nationalforests.org/

**National Park Foundation (NPF)**

As the official nonprofit partner of the National Park Service, NPF generates private support and builds strategic partnerships to protect and enhance America's national parks for present and future generations. Its mission is to directly support the National Park Service. Chartered by Congress in 1967, NPF grew out of a legacy of park protection that began over a century ago, when ordinary citizens took action to establish and protect our national parks. NPF focuses on promoting programs and projects that protect precious landscapes, wilderness, historical sites, and places of cultural significance. It works to keep trails clear, partners with collaborators on kids' outdoors programs, and raises and allocates funds to keep national parks safe. Official website: https://www.nationalparks.org/

**Reagan-Udall Foundation for the FDA**

The Reagan-Udall Foundation is a private 501(c)3 established in 2007 and created to support the mission of the U.S. FDA to help equip its staff with the highest caliber regulatory science and technology to enhance the safety and effectiveness of FDA-regulated products. The central focus of the foundation is to assist in the creation of new, applied scientific knowledge, tools, standards, and approaches the FDA needs to evaluate products more effectively, predictably, and efficiently—and thereby enhance the agency's ability to protect and promote the health of the American public. The Reagan-Udall Foundation serves as a crucial conduit between the FDA and the public, providing a means for the FDA to interact directly with stakeholders, including industry and consumers. The foundation does not participate in regulatory decision-making or offer advice to the FDA on policy matters. Official website: https://reaganudall.org/

**In-Q-Tel Inc.**

In-Q-Tel is a 501 (c)(3) founded in 1999 with the mission to deliver the most sophisticated source of strategic technical knowledge and capabilities to the U.S. government and its allies. In-Q-Tel explores emerging technology and provides insight, powering its partners with the ability to better anticipate and advance national security in the 21st century. In-Q-Tel plays a distinct role at the intersection of the government, venture capital, and the startup work to make investments in technology.[234] Official website: https://www.iqt.org/about-iqt/

[234] Information provided in this appendix combines previous research conducted by CRS and ITIF. In addition, publicly available documents from foundation websites were used to add additional information.
"Agency-Related Nonprofit Research Foundations and Corporations." Congressional Research Service.
Hart, David M, and Jetta Wong. "Mind the Gap: A Design for a New Energy Technology Commercialization Foundation." ITIF. Information Technology and Innovation Foundation, May 11, 2020. https://itif.org/publications/2020/05/11/mind-gap-design-new-energy-technology-commercialization-foundation.

# Appendix G: Panel and Study Team Biographies

## Panel

**Peter Winokur** (Chair), President & Founder, Integrated Safety Solutions, LLC; Chairman Emeritus, Defense Nuclear Facilities Safety Board; Former Chairman, Defense Nuclear Facilities Safety Board; Senior Policy Analyst, National Nuclear Security Administration; Congressional Fellow, Office of Senator Harry Reid; Manager, Radiation Technology & Assurance, Sandia National Laboratories; President, IEEE Nuclear and Plasma Sciences Society; Member, IEEE-USA Board of Directors; 40 years of experience as a scientist and engineer in the field of radiation effects science, technology, and hardness assurance in support of military and space systems. Fellow, Institute of Electrical and Electronic Engineers and American Physical Society.

**Dan Arvizu**, Chancellor, New Mexico State University System; Former Senior Advisor and CTO Elemental Group Emerson Collective; Former Director, National Renewable Energy Laboratory; Executive Vice President, Midwest Research Institute; Senior Vice President and Chief Technology Officer, Federal and Industrial Client Groups, CH2M HILL Companies; Former executive roles at Sandia National Laboratories including Director of Advanced Energy Programs, Director of Technology Commercialization, and Director of Materials and Process Sciences; Member of Technical Staff, Customer Switching Laboratory, AT&T Bell Telephone Labs. Former Chairman National Science Board. Currently serves on the Board of the Western Electricity Coordinating Council; the Advisory Board of the Stanford Precourt Institute for Energy; Member of the National Academy of Engineering and the National Academy of Public Administration.

**Richard Callahan**, Professor at the University of San Francisco, with a joint faculty appointment in both the School of Nursing and Health Professions and the School of Management, and co-Director of the MPH program. He is current Editor in Chief of the *International Journal of Public Leadership*. He was a Fulbright Specialist Program Fellow for Istanbul Aydin University, Turkey and visiting researcher at Oxford University. For over 20 years, he has designed and delivered leadership programs international, nationally and for state governments across a range of government and nonprofit organizations. He is a Principal in the Consulting firm, TAP International.

**Mridul Gautam**, President, Nevada Research and Innovation Corporation; Vice President for Research and Innovation, Research & Innovation, University of Nevada, Reno; Professor, Mechanical Engineering, University of Nevada, Reno; Associate Vice President for Research, Office of Research and Economic Development, West Virginia University; Vice President WVU Research Corporation, West Virginia University; Professor, Mechanical Engineering, West Virginia University; Associate Professor Mechanical Engineering, West Virginia University; Assistant Professor, Mechanical Engineering, West Virginia University.

**Beth Gazley**, Professor, School of Public & Environmental Affairs, Indiana University-Bloomington; Senior Associate, The Parisky Group Consulting Firm; Development Officer, Office of Development and Alumni Relations, University of New Haven; Membership Services Manager, Business Executives for National Security Inc.

**James Hendler**, Professor, Computer Science, Rensselaer Polytechnic Institute; Professor, Computer Science, University of Maryland; Program Manager/Chief Scientist (IPA), Information Systems, Defense Advanced Research Projects Agency; Open Data Advisor, New York State (unpaid), NYS Government; Internet Web Expert (unpaid), Data.gov project, IPA to GSA, working w/OSTP; Member Advisory Committee , Homeland Security Science and Technology Adv. Comm, DHS; Board Member, Board on Research Data and Information, National Academy Sciences, Engineering and Medicine; Director's Advisory Committee Member, Nat'l Security Directorate, Pacific Northwest National Laboratories.

**Academy Study Team**

**Brenna Isman**, Director of Academy Studies. Ms. Isman has worked at the Academy since 2008 and oversees the Academy studies, providing strategic leadership, project oversight, and subject matter expertise to the project. Prior to this, Ms. Isman was a Project Director managing projects focused on organizational governance and management, strategic planning and change management. Her research engagements have included working with the National Aeronautics and Space Administration, the Environmental Protection Agency, the Social Security Administration, the Department of Veterans Affairs, as well as multiple regulatory and Inspector General offices. Prior to joining the Academy, Ms. Isman was a Senior Consultant for the Ambit Group and a Consultant with Mercer Human Resource Consulting. Ms. Isman holds a Master of Business Administration (MBA) from American University and a Bachelor of Science (BS) in Human Resource Management from the University of Delaware.

**Mark Thorum**, Project Director. Dr. Thorum joined the Academy as a Senior Advisor and Project Director in May 2019. Dr. Thorum previously served as the Assistant Inspector General (AIG) for Inspections and Evaluations and the AIG for Management and Policy with the Office of Inspector General (OIG), Export-Import Bank of the United States. Dr. Thorum has more than 25 years of experience with independent evaluation, structured finance, risk mitigation, and capital markets advisory with both the federal government and international financial institutions. He holds a Ph.D. from the Virginia Polytechnic Institute and State University - School of Public and International Affairs. He received a M.A. from The Johns Hopkins University – School of Advanced International Studies, and a D.E.A. from the Institut d'études politiques de Paris (Institute of Political Studies) Paris, France.

**Sujai Shivakumar**, Senior Advisor. Dr. Shivakumar is an expert in American technology and innovation policy, with nearly two decades of experience in directing studies, convening high-level dialogue, and preparing reports at the National Academies of Sciences, Engineering, and Medicine. He has extensive experience in the assessment of public-private technology partnerships. Dr. Shivakumar directed the Academies' study of National Innovation Programs for Flexible Electronics and its flagship study of The Supply Chain for Middle-Skill Jobs, the Academies' Innovation Policy Forum, an assessment of the Small Business Innovation Research (SBIR) Program and was the lead researcher on the Academies' review of the U.S. Manufacturing Extension Partnership. He is a recipient of the National Academies Distinguished Individual Service Award. Dr. Shivakumar holds a doctorate in economics from George Mason University and was an Earhart Foundation scholar at the Ostrom Workshop in Political Theory and Policy Analysis at Indiana University-Bloomington. He is the author of The Constitution of Development

(Macmillan, 2005) and co-author with Nobel Laureate Elinor Ostrom of The Samaritan's Dilemma, The Political Economy of Development Aid (Oxford UP, 2005).

**Phillip A. Singerman**, Senior Advisor. Dr. Singerman is a recognized national innovator in public-private partnerships to promote economic development, job creation, and nation security through technology development, transfer and deployment. Dr. Singerman recently stepped down from federal service after nine years as the first Associate Director for Innovation and Industry Services, National Institute of Standards and Technology (NIST). In this position he led NIST's unique national technology transfer program. As one of NIST's three Associate Directors, Dr. Singerman was responsible for NIST's suite of advanced manufacturing deployment and technical assistance programs. Previously Dr. Singerman served as U.S. Assistant Secretary of Commerce for Economic Development and directed the Economic Development Administration (1995- 1999). Dr. Singerman was the founding chief executive of Philadelphia's Ben Franklin Partnership for Technological Innovation (1983-1995) and the Maryland Technology Development Corporation (1999- 2005). Dr. Singerman received his B.A. from Oberlin College and his PhD from Yale University, and taught at Barnard College (Columbia University), Yale University, and the Fels Center of Government (University of Pennsylvania).

**Kaitlyn Blume**, Senior Advisor. Ms. Blume serves as the President and CEO's point of contact to the Academy's nearly 950 Fellows, the nation's leading public administrators, managers, and scholars. Prior to joining the Academy, Ms. Blume served as the Director of Strategic Partnerships at the Nonprofit Leadership Alliance where she built strategic connections with national nonprofits. She has also served as the Director of Member Services at the National Human Services Assembly overseeing the recruitment, retention and engagement of 80+ national nonprofit members. Ms. Blume is a graduate of Wake Forest University with a BA in Anthropology and holds a Master's in Public Administration with a specialization in nonprofit management and sustainability from Clemson University. She has been actively engaged and served many roles in several nonprofit organizations including serving as a board member for Flying Scarfs, an organization creating solutions for peace, stability and economic freedom in Afghanistan.

**Sharon Yoo**, Research Analyst. Ms. Yoo provides research and analytical support to several Academy initiatives and draws on her international development, education, and technology policy expertise. She has extensive research experience and has published in these topics. She previously worked with organizations such the UNDP, MIT Media Laboratory, and several technology start-ups. Her previous academic research includes the U.S. secondary and tertiary education policy and workforce readiness, Pakistan's and India's energy crisis, tuberculosis outbreak in Asia, and unique applications of artificial intelligence. She is proficient in Korean, Hindi/Urdu, and English. She holds a dual degree masters from The Johns Hopkins University School of Advanced International Studies and Harvard Graduate School of Education.

**Kyle Romano**, Senior Research Associate. Mr. Romano has provided research support for several Academy studies. Most recently, he has served on Academy projects assessing the alignment of the Federal Bureau of Prisons with its healthcare mission, and the U.S. Forest Service's research and development enterprise. He graduated from the Indiana University School of Public and Environmental Affairs where he earned a Master of Public Affairs. He attended the

University of Central Florida for his undergraduate studies where he earned a B.A. in Political Science and a B.S. in Legal Studies.

**Allen Harris**, Research Associate. Mr. Harris joined the Academy in October 2019 as a Research Associate. Prior to joining the Academy, he had numerous internships including working at the Brookings Institute and the U.S.–Japan Bridging Foundation. Most recently he was working for an Impact Investor on projects including affordable housing in U.S. National Parks and bio-herbicide development in Kenya. Mr. Harris graduated from the University of St. Andrews, Scotland, in 2018 earning an MA, Honors in International Relations and Modern History.

# Appendix H: List of Figures and Charts

# Appendix I: Additional Information Regarding Technology Transfer

## Congressional Interest

Legislation that addresses some aspect of technology transfer and transitions include the:

- Energy Policy Act of 2005 (Public Law 109-58)*[235]
- The America COMPETES Act of 2007 (America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education and Science) (Public Law 110-69)[236]
- Department of Energy Research and Innovation Act of 2018 (Public Law 115-246)*[237]
- House Energy and Water Appropriations Subcommittee Report – FY2020[238]
- Senate Energy and Water Appropriations Subcommittee Report – FY2020[239]
- Energizing Technology Transfer Act of 2020[240]

** Enacted*

In addition, congressional interest is indicated in language in the Energy and Water Appropriations Subcommittee Reports.[241]

### *The Energy Policy Act of 2005 (Public Law 109-58)*[242]

The Energy Policy Act of 2005 was the first omnibus energy legislation enacted in more than a decade. Spurred by rising energy prices and growing dependence on foreign oil, the new energy law was shaped by competing concerns about energy security, environmental quality, and economic growth.[243]

This comprehensive bill, with 18 titles in 551 pages, proposes specific activities at DOE to

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235 109th Congress, Public Law 109-58 "The Energy Policy Act of 2005". https://www.congress.gov/bill/109th-congress/house-bill/6/text
236 110th Congress, Public Law 110-69 "America COMPETES Act". https://www.congress.gov/110/plaws/publ69/PLAW-110publ69.pdf
237 115th Congress, Public Law 115-246 "Department of Energy Research and Innovation Act". https://www.congress.gov/bill/115th-congress/house-bill/589/text
238 U.S. House of Representatives Appropriations Committee, Conference Report on the Energy and Water Development and Related Agencies Appropriations Bill, 2020. https://www.congress.gov/congressional-report/116th-congress/house-report/83/1
239 U.S. Senate Appropriations Committee, Conference Report on the Energy and Water Development Appropriations Bill, 2020, page 69. https://www.congress.gov/congressional-report/116th-congress/senate-report/102/1
240 116th Congress, H.R. 8273 "Energizing Technology Transfer Act". https://www.congress.gov/bill/116th-congress/house-bill/8273/text
241 U.S. House of Representatives Appropriations Committee, Conference Report on the Energy and Water Development and Related Agencies Appropriations Bill, 2020. https://www.congress.gov/congressional-report/116th-congress/house-report/83/1; U.S. Senate Appropriations Committee, Conference Report on the Energy and Water Development Appropriations Bill, 2020, page 69. https://www.congress.gov/congressional-report/116th-congress/senate-report/102/1
242 109th Congress, Public Law 109-58 "The Energy Policy Act of 2005". https://www.congress.gov/bill/109th-congress/house-bill/6/text
243 United States Congressional Research Service, *Agency-Related Research Foundations and Corporations*. Agency-Related Nonprofit Research Foundations and Corporations (congress.gov)

support technology transfer. Among the notable requirements are the following:

Title IX - Research and Development

(Sec.917). Advanced Energy Efficiency Technology Transfer Centers DOE is directed to create a grant program to support state and local governments, universities, and nonprofit organizations to create a network of Advanced Energy Technology Transfer Centers.

Title X – Department of Energy Management Improved Technology Transfer of Energy Technologies

Title X establishes a set of policies and processes to "improve[d] technology transfer of energy technologies."

(Sec. 1001). DOE shall appoint a Technology Transfer Coordinator to be the Secretary's principal advisor on technology transfer and commercialization; establish a Technology Transfer Working Group consisting of representatives of the National Laboratories and single-purpose research facilities; and establish an Energy Technology Commercialization Fund, using 0.9 percent of the amount made available to DOE in each fiscal year for applied energy research, development, demonstration, and commercial application, to provide matching funds with private partners.

(Sec. 1002). Technology Infrastructure Program DOE shall establish a Technology Infrastructure Program to improve the ability of National Laboratories and single- purpose research facilities to stimulate the development of technology clusters; benefit from commercial research, technology, products, processes, and services; and exchange scientific and technological expertise with nonfederal entities.

(Sec. 1003). Small Business Advocacy and Assistance Each National Laboratory (and each single-purpose research facility, if required by the Secretary of Energy) shall appoint a small business advocate and a small business advocacy program.

(Sec. 1004). DOE shall ensure that programs authorized by this act include an outreach component to provide information to manufacturers, consumers, engineers, and other specified groups.

(Sec. 1005). Relationship to Other Laws, the legislation specifically notes that DOE technology transfer activities are embedded in a broader set of existing federal and DOE specific legislation, such as: The Atomic Energy Act of 1954, the Federal Nonnuclear Energy R&D Act of 1974; the Energy Policy Act of 1992, the Stevenson-Wydler Technology Innovation Act of 1980; the Bayh-Dole Act, and other applicable acts.

(Sec. 1007). Other Transactions Authority. DOE is granted authority to enter into "other transactions" (in addition to contracts, cooperative agreements, and grants) to fund research, development, and demonstration projects.

(Sec. 1008). Prizes for Achievement in Grand Challenges of Science and Technology. DOE may award cash prizes for breakthrough achievements in research, development, demonstration, and commercial application potentially applicable to the mission of the

Department.

(Sec. 1010). University Collaboration Within two years of enactment, DOE shall report to Congress on the feasibility of using DOE grants, contracts, and cooperative agreements to promote collaborations between major universities and other colleges and universities. DOE shall also consider providing incentives in its grants, contracts, and cooperative agreements to increase the inclusion of small and minority-serving institutions of higher learning.

Several sections required reports to Congress.

### ***The America COMPETES Act of 2007 (America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education and Science) (Public Law 110-69)*** [244]

Among its many provisions created ARPA-E (Advanced Research Projects Agency – Energy), modeled on the widely heralded DARPA (Defense Advanced Research Projects Agency) with the mission "to overcome long-term and high-risk technology barriers in the development of energy technologies" in order to "enhance the economic and energy security of the United States through the development of energy technologies….and to ensure that the United States maintains a technological lead in developing and deploying advanced energy technologies." The legislation was based upon recommendations made by the National Academy of Sciences Rising Above the Gathering Storm Report (2005).[245]

### ***The Department of Energy Research and Innovation Act of 2018 (P.L. 115-246)***[246]

Title I – Laboratory Modernization and Technology Transfer Act, (Section 103) provides a "(a) Sense of Congress on Accelerating Energy Innovation," which states that "(2) accelerating the pace of clean energy innovation in the United States calls for (A) supporting existing research and development programs at the Department and the world-class National Laboratories: (B) exploring and developing new pathways for innovators, investors and decision-makers to leverage the resources of the Department for addresses the challenges and comparative strengths of geographic regions;… (4) a regional approach to innovation can bridge the gaps between local talent, institutions, and industries to identify opportunities and convert United States investment into domestic companies…";

(Sec 102) added a number of refinements to existing technology transfer activities, including permitting laboratory Directors to "carry out early-stage and pre-commercial technology demonstration activities to remove technology barriers that limit private sector interest and demonstrate potential commercial applications of any research and technology arising from National Laboratory activities";

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[244] 110th Congress, Public Law 110-69 "America COMPETES Act". https://www.congress.gov/110/plaws/publ69/PLAW-110publ69.pdf

[245] The National Academy of Sciences, Engineering, and Medicine, *Rising Above the Gathering Storm*. https://www.nap.edu/catalog/11463/rising-above-the-gathering-storm-energizing-and-employing-america-for

[246] 115th Congress, Public Law 115-246 "Department of Energy Research and Innovation Act". https://www.congress.gov/bill/115th-congress/house-bill/589/text

(Sec 104) proscribed overhead in LDRD funding;

(Sec 105) created a Research Grants Database;

(Sec 106) required a Technology Transfer and Transition Assessment within one year of passage;

(Sec 107) provided specific guidance to the ACT pilot program, which was created under existing authority, including providing maximum authority to the labs, eliminated cost-sharing requirements for non-profit organizations and educational institutions, prescribed specific application process, operations, and activities for new Energy Innovation HUBS and existing HUBS (Sec 206), and Energy Frontier Research Centers (Sec 303).

Other proposed legislation includes the Small Business Partnering with National Laboratories Act of 2019, which authorizes the pilot Small Business Voucher program and extends it to all the labs, clarifies and reduces the small business cost-share requirement and authorizes $25 million annually.

The Technology Transitions Act of 2019, Sec 2, names the OTT Coordinator as the Chief Commercialization Officer, reporting directly to the Secretary, and requires a review of applied energy projects.[247]

The Fossil Energy Research and Development Act of 2019 (House Report 116-510) extends to the National Energy Technology Laboratory (NETL), a GoGo, authorities that GoCos have including Special Hiring Authority, and authorizing between 2 percent and 4 percent of funding for a Directed Research and Development program (DR&D).

***House Energy and Water Appropriations Subcommittee Report – FY2020[248]***

Direction on "Research and Development Policy" is also provided through Report Language from the Congress. For example, from the FY2020 Senate Appropriations Subcommittee Report:

"The budget request again proposes to focus the Department solely on early-stage research and development activities at the expense of medium- and later-stage research and development, including deployment, demonstration, and other approaches to spur innovation. The Committee rejects this short-sighted and limited approach, which will ensure that technology advancements will remain in early-stage form and are unlikely to integrate the results of this early-stage research into the nation's energy system. While early-stage research and development has an appropriate place in a balanced research portfolio, the Committee strongly believes that a focus on only early stage activities will forego the nation's scientific capabilities in medium- and later-stage research and development and will not fully realize the technological advancements that can and should happen as a result of the Department's applied energy activities. The Committee provides robust funding to support a comprehensive, balanced approach that also includes medium- and later-stage research, development, deployment, and demonstration activities. The Committee directs

[247] 116th Congress, S. 2688 "Technology Transitions Act of 2019". https://www.congress.gov/bill/116th-congress/senate-bill/2688/text

[248] U.S. House of Representatives Appropriations Committee, Conference Report on the Energy and Water Development and Related Agencies Appropriations Bill, 2020. https://www.congress.gov/congressional-report/116th-congress/house-report/83/1

the Department to follow this comprehensive approach in each applied energy research and development program office and expend funding in an expeditious manner, to include the timely issuance of funding opportunity announcements and awards of funds. To capitalize on the research infrastructure and expertise at universities across the country, the Committee encourages the Department to increase opportunities for universities to compete for funding within the Department's portfolio of research."

***Senate Energy and Water Appropriations Subcommittee Report – FY2020[249]***

Direction on "Research and Development Activities" is further provided through Report Language from the Congress. For example, from the FY2020 Senate Appropriations Subcommittee Report:

"The Department is directed throughout all of its programs to maintain a balanced portfolio of early-, mid-, and late-stage research, development and market transformation activities that will deliver innovative energy technologies, practices, and information to American consumers and industry. While Federal investment plays a greater role in early stage research, a balanced portfolio must be inclusive of Federal investment in mid-to-late research activities, including field evaluation of early-stage technology to promote testing and data collection in a real-world setting' to attract private sector cost share that will advance technology to market; and provide a bridge to small businesses, cities or small utilities with fewer resources and tools to participate in energy infrastructure planning."[250]

***The Energizing Technology Transfer Act of 2020[251]***

Reviewed at a House hearing on July 17, 2020 and passed by the House Science Committee, the Energizing Technology Transfer Act presents a comprehensive updating of technology transfer provisions in the Energy Policy Act.

Section 2 Finds "(1) a rapid and substantial investment in clean energy innovation is needed"; "(2) clean energy technologies face unique obstacles to commercial application, including high up-front capital costs, long development times, and the need to displace incumbent technologies in highly regulated markets"; "(3) multiple technology development gaps exist in the clean energy innovation and commercial application landscape that are not currently met by private sector investment alone"; "(4) Federal investments in technology transfer and demonstration programs help fill existing gaps…"; "(5)…the Department of Energy must show significant leadership in enabling the transfer of new technologies to the private sector, particularly through the Office of Technology Transitions."

<u>Title I – National Clean Energy Technology Transfer Programs</u>

Section 101 authorizes a Clean Energy Innovation Partnership Program with an authorized funding level of $50 million/yr. for FY21-25;

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[249] U.S. Senate Appropriations Committee, Conference Report on the Energy and Water Development Appropriations Bill, 2020, page 69. https://www.congress.gov/congressional-report/116th-congress/senate-report/102/1
[250] *Ibid*, page 69.
[251] 116th Congress, H.R. 8273 "Energizing Technology Transfer Act". https://www.congress.gov/bill/116th-congress/house-bill/8273/text

Section 102 authorizes a National Clean Energy Incubator program with an authorized funding level of $15 million/yr. for FY21-25;

Section 103 authorizes a Clean Energy Technology University Prize Competition with an authorized funding level of $1 million/yr. for FY21-25;

Section 105 authorizes $3 million annually for the Office of Technology Transitions.

Title II - Supporting Technology Development at the National Laboratories,

Section 201 authorizes a Lab Partnering Service Pilot Program through the development of a website, with an authorized funding level a total of $3.7 million/yr. for FY21-23;

Section 202 authorizes funding $25 million/yr. for FTY21-25 for the Lab Embedded Entrepreneurship Program;

Section 203 amends the Small Business Voucher Program provisions in the Energy Policy Act and authorizes $25 million/yr. for FY21-25;

Section 204 prescribes criteria for an Entrepreneurial Level Program;

Section 205 prescribes criteria for Lab Employee Outside Employment Activities and delegates authority to the Lab Directors;

Section 206 amends the Technology Commercialization Fund provisions of the Energy Policy Act and specifies certain criteria for the program and authorizes .9 percent of applied R&D funds for the program;

Section 207 delegates signature authority to Lab Directors for agreements under $1 million encompassing CRADAs, SPPs, Prize Competitions, ACTs, and other agreements as determined by the Secretary and Lab Directors.

Title III - Department of Energy Modernization

Section 1012 amends the Technology Transfer provisions of the Energy Policy Act to specify the responsibilities of the Technology Transfer Coordinator and authorizes $20 million/yr. for FY21-25.

Section 302, Management of Demonstration Projects, establishes a program to conduct project management and oversight of demonstration projects that receive more than $50 million in funding from the Department, and appoint at least two FTEs to manage the program;

Section 303 Streamlining Prize Competitions, amends America COMPETES and directs the Secretary to designate one FTE to serve as a point of contact;

Section 304, Milestone-Based Demonstration Projects specifies criteria for designate at least one FTE to coordinate prize competitions;

Section 306 provides for Special Hiring Authority;

Section 307 requires a report 3 years after enactment of the legislation by the NASEM “on programmatic gaps that exist to advance the commercial application of technologies developed at the National Laboratories."

The Clean Economy Jobs and Innovation Act (HR4447), passed by the full House on September 24, 2020, incorporated The Energizing Technology Transfer Act as Title VIII – "Technology Transfer." The new language somewhat expands upon the original bill; and includes in the Regional Clean Energy Innovation Partnerships, as a definition:

"Frontline Communities - The term 'frontline community' means a community with significant representation of communities of color, low- income communities, or Tribal and indigenous communities, that experiences, or is at risk of experiencing higher or more adverse human health or environmental effects."

This definition clarifies one of the Purposes of the Program, to "(5) support the expansion of clean energy tools and technologies to low-income and frontline communities," and is consistent with the General provision to "support [of] regional clean energy innovation partnerships that… (4) improve economic development outcomes in economically distressed areas."

## DOE Commissioned Studies

### Studies Summarized

- The Interim Report of the Secretary of Energy Advisory Board (SEAB) National Laboratory Task Force (TF) (SEAB Task Force on DOE national Laboratories, 2014)[252]
- Final Report - Commission to Review the Effectiveness of the National Energy Laboratories (CRENEL) (2015)[253]
- Innovation Working Group Report of the Secretary of Energy Advisory Board (2020)[254]

### *The Interim Report of the Secretary of Energy Advisory Board National Laboratory Task Force (SEAB Task Force on DOE national Laboratories, 2014)*[255]

"Executive Summary…identifies the constraints on and evaluates the effectiveness of laboratory operations that impact the performance and efficiency of the DOE National Laboratories. The TF stresses the overriding importance of two actions: clarifying the authorities and responsibilities of the entities involved in laboratory management and adopting a disciplined process for implementing change."

"The TF report further proposes targeted 'experiments' in three areas:… (2) technology transfer as a means for creating value for the private sector…" The TF presented a Historical Context,

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[252] United States Department of Energy, *Interim Report of the Task Force on DOE National Laboratories*. https://www.energy.gov/seab/downloads/interim-report-task-force-doe-national-laboratories

[253] United States Department of Energy, *Commission to Review the Effectiveness of the National Energy Laboratories*. https://www.energy.gov/labcommission/downloads/final-report-commission-review-effectiveness-national-energy-laboratories

[254] U.S. Department of Energy, SEAB Innovation Working Group, *Innovation Working Group Report*, pages 7-11. https://www.energy.gov/sites/prod/files/2020/05/f74/SEAB_Inno_Preliminary%20Findings%20%28Final%29.pdf

[255] United States Department of Energy, *Interim Report of the Task Force on DOE National Laboratories*. https://www.energy.gov/seab/downloads/interim-report-task-force-doe-national-laboratories

Process and Observations, and Findings.[256] It opined, "There is a general impression that the laboratories do not have a strong record stimulating technology transfer, particularly in comparison with universities…" and it was "surprised to learn that the department does not have a policy stating that technology transfer is a legitimate laboratory objective."

Of a total of 15 recommendations, the TF offered five recommendations specific to technology transfer, including:

- "3.1 Issue policy statement that technology transfer activities are part of the DOE National Laboratories mission.
- 3.2 Organize technology transfer activities using a decentralized approach, including flexible experimental agreements to facilitate rapid Laboratory-industry engagements [see attachment –Table 2, p 15, for a Summary of TF Recommendations and pp. 30-32 for specific tech transfer recommendations)"

### *Final Report - Commission to Review the Effectiveness of the National Energy Laboratories*[257] *(2015)*

CRENEL was established by Public Law 113-76, charged with reviewing the 17 DOE National Laboratories, and approved its final report on October 23, 2015. The Commission's findings and recommendations are grouped around six themes, including "Maximizing impact," of which the Commission observes.[258]

"A great deal of money and talent has been invested to create scientific and technical capabilities that are critically important for the Nation's security and economic competitiveness. Realizing the full potential of the laboratories requires a much greater effort to tap their capabilities, especially in support of regional and national competitiveness. DOE and the laboratories must work to break down barriers to external collaboration with small and large businesses, academia, and other Federal agencies."

Innovative technology transfer and commercialization mechanisms should continue to be pursued, and best practices in other sectors, including academia, should be examined. Congress and DOE should continue to support leading edge S&T user facilities, making sure to continue using scientific community input and peer review processes to determine future priorities for new and upgraded facilities."

The Commission analyzed Support of Other Agencies, Collaboration with the Academic Community, Partnering with Industry and Transitioning Technology, and Operating User Facilities and offered 7 specific recommendations, including "Recommendation 25: All DOE Programs and laboratories should fully embrace the technology transition mission and continue improving the speed and effectiveness of collaborations with the private sector.[259] Innovation

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256 *Ibid,* pages 26-32.
257 United States Department of Energy, *Commission to Review the Effectiveness of the National Energy Laboratories*. https://www.energy.gov/labcommission/downloads/final-report-commission-review-effectiveness-national-energy-laboratories
258 *Ibid,* pages v-vi.
259 United States Department of Energy, *Commission to Review the Effectiveness of the National Energy Laboratories,* pages 47-52; 187-215. https://www.energy.gov/labcommission/downloads/final-report-commission-review-effectiveness-national-energy-laboratories

technology transfer mechanisms should continue to be pursued and best practices in other sectors, including academia, should be examined."

### *Innovation Working Group of the Secretary of Energy Advisory Board (2020)*[260]

The Innovation Working Group of the Secretary of Energy Advisory Board also discussed technology transfer in its "Preliminary Findings":[261]

"III. Foster Faster Industry-DOE Collaboration and Communications

a. Understand the state of industry engagement today

b. Enhance shared understanding of the state of play and where industry can engage

c. Improve understanding and access to national assets important to energy innovation

d. Reduce the administrative friction of working with DOE

  a) Improve the speed and ease of contracting (simplify SPPs, CRADAs, ACTs, NPUAs, and streamline the approval process

  b) Understand time to contract for all offices/facilities; share best practices; measure and publish contracting times and set goals for improvement…

  c) Provide the capability to enhance understanding and the training of how to utilize various DOE contract instruments

  d) Common DOE Engagement Method. Once learned [by industry], the process should be identical for engaging other parts of the DOE complex.

IV. Leverage Innovative Funding Approaches

a. Reimagine Access of Small Businesses to DOE SBIR funding

b. Address gaps in funding for the non-technical aspects of moving technologies from the laboratory to the market, such as access to experts and facilities…

c. Investigate Innovative DOD Programs

d. Consider Further use of Other Transaction Authority"

## <u>External Studies</u>

Studies external to the Department of Energy that the Academy reviewed for this report include:

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[260] U.S. Department of Energy, SEAB Innovation Working Group, *Innovation Working Group Report*. https://www.energy.gov/sites/prod/files/2020/05/f74/SEAB_Inno_Preliminary%20Findings%20%28Final%29.pdf
[261] *Ibid*, pages 7-11.

- Technology Transfer: Clearer Priorities and Greater Use of Innovative Approaches Could Increase the Effectiveness of Technology Transfer at Department of Energy Laboratories (U.S. Government Accountability Office, 2009)[262]
- Positioning DOE's Labs for the Future: A Review of DOE's Management and Oversight of the National Laboratories (The National Academy of Public Administration, 2013)[263]
- Audit Report: Technology Transfer and Commercialization Efforts at the Department of Energy's National Laboratories (U.S. Department of Energy, Office of Inspector General, 2014)[264]
- Federal Research: Additional Actions Needed to Improve Licensing of Patented Laboratory Inventions (U.S. Government Accountability Office, 2018)[265]

***Technology Transfer: Clearer Priorities and Greater Use of Innovative Approaches Could Increase the Effectiveness of Technology Transfer at Department of Energy Laboratories (U.S. Government Accountability Office, 2009)[266]***

Three years after the passage of the Energy Policy Act of 2005, which required the Secretary of Energy "to appoint a technology transfer coordinator for the department and to develop technology transfer goals and a plan for implementing them," Congress requested GAO to examine "(1) the nature and extent of technology transfer at DOE laboratories, (2) the extent to which DOE can measure the effectiveness of technology transfer activities at its laboratories, and (3) factors affecting technology transfer and approaches that may have potential for improving technology transfer"[267]

GAO reported that DOE generally recognized four primary types of activities widely regarded as technology transfer: cooperative research and development, work for others, licensing, and user-facility agreements.

GAO presented in Appendix II of its report data on these four mechanisms for FY2006-2008 disaggregated by National Laboratory. The attached table shows activity in 2008 by number of agreements and Contributed Funds or Associate Revenue by Private Partners. Private partners utilize CRADAs while federal agencies utilize Work for Others.

GAO found that while the labs "routinely share their technologies, capabilities and knowledge with outside entities, it is difficult to assess the full extent of technology transfer activities because policies defining technology transfer are unclear and headquarters and laboratory officials do not always agree on which activities should be included." GAO noted that DOE officials do not agree

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[262] United States Government Accountability Office, *Technology Transfer*. https://www.gao.gov/assets/300/290963.pdf
[263] National Academy of Public Administration, *Positioning DOE's Labs for the Future*. https://www.napawash.org/uploads/Academy_Studies/13_01_Department_of_Energy_Review_of_Departmental_Management_and_Oversight_of_the_National_Laboratories.pdf
[264] United States Department of Energy, Office of Inspector General, *Technology Transfer and Commercialization Efforts*. https://www.energy.gov/sites/prod/files/2014/02/f8/OAS-M-14-02.pdf
[265] United States Government Accountability Office, *Federal Research*. https://www.gao.gov/products/GAO-18-327
[266] *Ibid*.
[267] United States Government Accountability Office, *Technology Transfer,* page 3. https://www.gao.gov/assets/300/290963.pdf

on whether research conducted for other federal agencies through "work for others" should be considered technology transfer.

GAO also found that "DOE cannot determine its laboratories' effectiveness in transferring technologies outside DOE because it has not yet established department-wide goals for technology transfer and lacks reliable performance data."

GAO reported that officials at the 17 National Laboratories identified three primary challenges constraining technology transfer: "(1) competing staff priorities or gaps in expertise needed to consistently identify promising technologies or potential markets; (2) lack of funding to sufficiently develop or test some promising technologies to attract potential partners, and (3) lack of flexibility to negotiate certain terms of technology transfer agreements."

GAO recommended that the Secretary, working in concert with laboratory directors, take seven actions, including:

- "explicitly articulate department-wide priorities for DOE's technology transfer efforts;
- develop clear goals, objectives and performance measures in line with these priorities;
- clarify which activities qualify as technology transfer, including whether research sponsored by other federal agencies qualifies;
- Develop a comprehensive means of sharing information across laboratories and with private entities, such as Web-based clearinghouse for technologies ready for further development or commercialization"[268]

***Positioning DOE's Labs for the Future: A Review of DOE's Management and Oversight of the National Laboratories (The National Academy of Public Administration, 2013)***[269]

In 2013 Congress asked the National Academy of Public Administration to review how DOE oversees its contractor-operated labs, including a review of the performance metrics and systems that DOE uses to evaluate the performance of the labs. The report described in great detail the distinctive decentralized, delegated, and diverse approach that DOE Program Offices employ in managing its 16 FFRDCs.

In studying the specific questions related to lab management, the Academy concluded that they were part of a broader issue about defining and ensuring the future of the lab complex. The Study Team found that although there is room for improvement in both oversight and evaluation, for the most part, individual labs are successfully performing important DOE mission-related work, and evaluations are measuring key performance elements and holding labs accountable.

A key vehicle for DOE management's oversight of the Labs is the Performance Evaluation and Measurement Plan (PEMP), which is the basis for determining the annual fee award.

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[268] *Ibid*, pages 31-32.
[269] National Academy of Public Administration, *Positioning DOE's Labs for the Future*.
https://www.napawash.org/uploads/Academy_Studies/13_01_Department_of_Energy_Review_of_Departmental_Management_and_Oversight_of_the_National_Laboratories.pdf

Figure I.1 provides a matrix of Current Categories in DOE Labs' Annual Evaluation Plans and Reports, by Program/Mission, Operations, and Leadership.

## Figure I.1: Content Categories in DOE National Laboratories' Annual Evaluation Plans and Reports

**Table 5-1: Content Categories in DOE Labs' Annual Evaluation Plans and Reports [a]**

| OFFICE OF SCIENCE | NUCLEAR ENERGY (INL) | NNSA (details are for LLNL, FY 2011) | NNSA Strategic PEP | EERE (NREL) |
|---|---|---|---|---|
| **Program/Mission** | | | | |
| • Mission Accomplishment<br>• Design, Fabrication, Construction, and Operation of Research Facilities<br>• Program Management | • Deliver Transformational Science<br>• Deliver R&D Program Commitments – milestones<br>• Develop Capabilities for the Future<br>• Establish Broader, More Effective Collaborations<br>• Safety, Operations, and Stewardship | • Complete essential activities for core weapons program requirements<br>• Strengthen the foundation of deterrence through stockpile science, technology, and engineering<br>• Propose and implement strategies for sustaining a strong deterrent at low numbers compatible with START, NPR and CTBT goals[b]<br>• Execute Inertial Confinement Fusion Ignition and High Yield Campaign in support of stockpile stewardship<br>• Support non-proliferation and threat reduction<br>• Provide science, technology, and engineering excellence | • Nuclear Weapons Mission<br>• Broader National Security Mission<br>• Science, Technology, and Engineering Mission | • Advancing science and technology<br>• Science and technology management, analysis, and integration<br>• Accelerating commercialization and increasing deployment<br>• Major construction (set forth as separate set of goals in evaluation, i.e., not part of mission or operations category) |
| **Operations** | | | | |
| • Environment, Safety, and Health<br>• Business Systems<br>• Facilities and Infrastructure<br>• Security and Emergency Management | • Some inclusion (see 5th bullet above), focused on specific activities. Otherwise, operations are "expected [to show] adequate performance" and problems are handled through other contract provisions | • Support current and evolving mission performance by providing effective and efficient facilities and infrastructure<br>• Maintain effective environmental, safety, and health institutional programs<br>• Maintain secure operations in an efficient and effective manner in support of mission objectives<br>• Manage business operations in an effective and efficient manner while safeguarding public assets and supporting mission objectives | • Security, Infrastructure, Environmental Stewardship, and Institutional Management | • Business operations<br>• Security and emergency management<br>• Environment, safety, and health management<br>• Infrastructure development and site operations |
| **Leadership** | | | | |
| • Contractor leadership-stewardship<br>• (Goal 1 also includes leadership) | • Quality of leadership in management and operations | • Governance assures performance and creates long-term sustainable value for the institution | • Contractor leadership | • Enhancing leadership and creating lasting national value (included in mission goals in evaluation) |

[a] Categorization is the Academy's; lab sponsors use other terminology
[b] START: Strategic Arms Reduction Treaty; CTBT: Comprehensive Nuclear-Test-Ban Treaty; NPR: Nuclear Posture Review

(Source: The National Academy of Public Administration: Positioning DOE's Labs for the Future)[270]

Only two specific items in Program/Mission appear to address technology transfer: for NE (INL) "Establish Broader, More Effective Collaborations" and for EERE (NREL) "Accelerating commercialization and increasing deployment." Otherwise, the report does not directly address "technology transfer" issues.

[270] *Ibid.*

The report stated that "In all cases, the available award fee is small relative to the total lab budget. Further, in practice as demonstrated in Figure I.2 for FY 2011, which is typical for most years, all labs get most of their award fee, and only a small portion appears to be really 'at risk.'"

**Figure I.2: DOE Available Fee and Awarded Fee**

**Table 5-3: DOE Available Fee and Awarded Fee (FY 2011 Data for Labs Visited)**

| Site | Available Fee | Awarded Fee (millions) | Portion of Fee Awarded |
|---|---|---|---|
| Argonne | $5.3 | $5.0 | 94% |
| Berkeley | $4.5 | $4.2 | 94% |
| Fermi | $3.9 | $3.6 | 94% |
| INL | $18.7 | $17.4 | 94.3%/92.6%[a] |
| Lawrence Livermore | $29.8 | $26.3 | 88% |
| NREL | 7.8 | $7.2 | 93% |
| Oak Ridge | $11.2 | $10.5 | 94% |
| Sandia | $9.9 | $8.5 | 85% |

[a] The fee calculated against the evaluation criteria was 94.3% of the total available award fee; because of a safety incident, the fee was reduced to 92.6%.

(Source: The National Academy of Public Administration: Positioning DOE's Labs for the Future)[271]

***Audit Report: Technology Transfer and Commercialization Efforts at the Department of Energy's National Laboratories (U.S. Department of Energy, Office of Inspector General, 2014)***[272]

Issued in February 2014, the OIG reported opportunities to improve the effectiveness of the Department's management of its technology transfer and commercialization efforts. Specifically, the OIG found that the Department had not finalized quantitative performance metrics necessary for it to determine the success of its technology transfer and commercialization efforts, developed a forward-looking approach for investing in the Energy Technology Commercialization Fund required by the Energy Policy Act of 2005, and ensure that the National Laboratories were consistently treating their equity holdings in licensees received as part of their technology transfer efforts.

Of particular interest was the discussion of equity holdings by the labs. OIG found that 13 of the 16 sites had accepted equity from licensees, that different National Laboratories treated equity holdings differently, and that with the exception of two sites, equity holdings were not accounted

[271] National Academy of Public Administration, *Positioning DOE's Labs for the Future*.
https://www.napawash.org/uploads/Academy_Studies/13_01_Department_of_Energy_Review_of_Departmental_Management_and_Oversight_of_the_National_Laboratories.pdf
[272] United States Department of Energy, Office of Inspector General, *Technology Transfer and Commercialization Efforts*.
https://www.energy.gov/sites/prod/files/2014/02/f8/OAS-M-14-02.pdf

for or reported on the laboratory accounting records, and that as a group the labs did not consistently report on the extent of equity holdings.[273]

The OIG offered three recommendations:

1. Finalize the statutorily required Technology Transfer Execution Plan, which includes quantitative performance metrics to be used to evaluate laboratory technology transfer and commercialization activities.
2. Develop and implement a forward-looking approach to plan and execute the Energy Technology Commercialization Fund.
3. Provide guidance for the treatment of licensee equity held by the labs and their contractors.[274]

In its formal response to the report, management concurred with each of the recommendations and said each would be a priority following the hire of a new Technology Transfer Coordinator.[275]

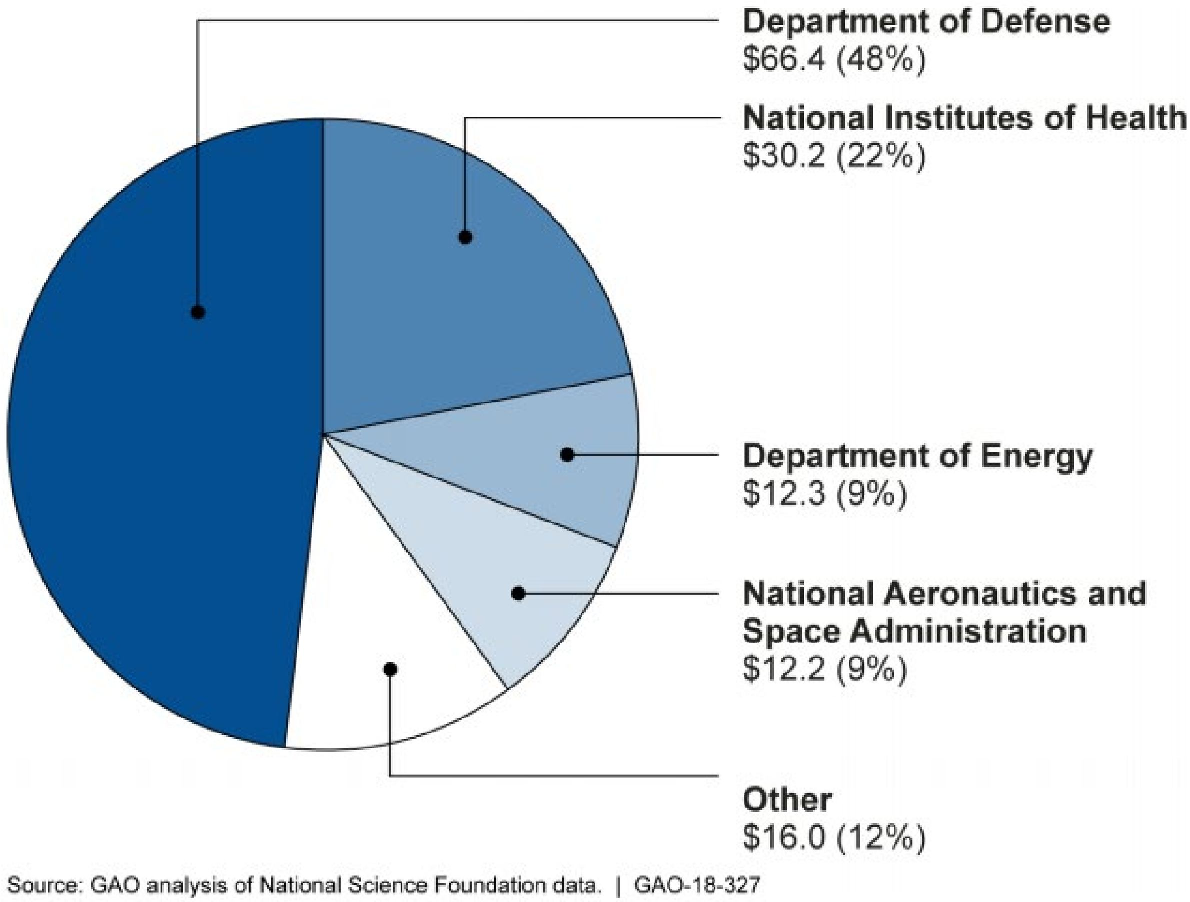
***Federal Research: Additional Actions Needed to Improve Licensing of Patented Laboratory Inventions (U.S. Government Accountability Office, 2018)***[276]

In 2018 Congress asked GAO to review agency practices for managing inventions developed at federal labs, with a particular focus on patent licensing. GAO examined (1) challenges in licensing patents and steps taken to address and report them and (2) information to guide establishing financial terms in patent licenses at DOE, DOE, NASA and NIH.

GAO found that the average federal R&D funding for FY2015-2017 was $66.4B for DOD, $30.2B for NIH, $12.3B for DOE, $12.2B for NASA, and $16.0B for Other agencies (Figure 1, p. 3), and found that in FY2014 of 222 licenses, DOE represented 116, DOD, 33, NASA 32, and NIH 41.

[273] *Ibid*, page 4.
[274] United States Department of Energy, Office of Inspector General, *Technology Transfer and Commercialization Efforts,* page 6. https://www.energy.gov/sites/prod/files/2014/02/f8/OAS-M-14-02.pdf
[275] *Ibid*, page 10.
[276] United States Government Accountability Office, *Federal Research*. https://www.gao.gov/products/GAO-18-327

**Figure I.3: Federal Research and Development Spending by Agency, Average for Fiscal Years 2015 to 2017 (Dollars in Billions)**




(Source: U.S. Government Accountability Office)

GAO identified several challenges facing the agencies, including in prioritizing patent licensing as part of their agency missions. Agency and lab officials "cited limited resources to conduct the range of activities related to patent licensing" and "that budget constraints affect the extent to which they can engage in patent licensing activities – including patent enforcement."[277] DOE officials noted that the nuclear labs do not focus on patenting.

GAO made 7 recommendations for Executive Action; the Secretary of Energy "should ensure that the agency or its labs document processes for establishing license financial terms, while maintaining flexibility to tailor the specific financial terms of each licenses."[278]

In its formal comment to GAO, DOE concurred with the recommendation and stated that it "intends to coordinate with the national labs to develop and document common practices in an attempt to make consistent some of the approaches to negotiating patent license financial terms. Although specific processes for establishing financial terms cannot be prescribed from the

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[277] *Ibid*, page 49.
[278] United States Government Accountability Office, *Federal Research,* pages 34-35. https://www.gao.gov/products/GAO-18-327

Departmental level, we will work with the labs to document minimum processes in order to mitigate some inconsistencies and ease inefficiencies across the labs." DOE estimated the completion date for this activity as July 2019.

In its detailed response, DOE listed the "many complex and nuanced considerations that the professional licensing negotiator must always consider…[which] factors are weighed against urgencies and alternate pathways to move the technology toward practical application." DOE noted that under federal law the contractor operated National Laboratories retain title to inventions, and that although DOE establishes certain non-financial requirements, "the financial portions of license agreements for national laboratory technologies are between the lab contractor and the licensing entity (licensee)."

## <u>External Studies – Advocacy</u>

### Studies Summarized

- Turning the Page: Reimagining the National Laboratories in the 21st Century Innovation Economy (Information Technology and Innovation Foundation, 2013)[279]
- Going Local: Connecting the National Laboratories to their Regions for Innovation and Growth (Brookings Institution, 2014)[280]
- The Department of Energy National Laboratories – Organizational design and management strategies to improve federal energy innovation and technology transfer to the private sector (Harvard Kennedy School, Belfer Center, 2017)[281]
- U.S. Energy R&D Architecture: Discrete Roles of Major Innovation Institutions (American Energy Innovation Council and Bipartisan Policy Center, 2019)[282]
- Energy Innovation: Supporting the Full Innovation Lifecycle (American Energy Innovation Council and Bipartisan Policy Center, 2020)[283]
- Collaboration Between Start-Ups and Federal Agencies: A Surprising Solution for Energy Innovation (Information Technology and Innovation Foundation, 2020)[284]

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[279] The Information Technology and Innovation Foundation, The Center for American Progress, and The Heritage Foundation, *Turning the Page*. http://www2.itif.org/2013-turning-the-page.pdf?_ga=2.241766658.1275738037.1605894047-1608027418.1605037154

[280] Brookings, *Going Local: Connecting the National labs to their Regions to Maximize Innovation and Growth*. https://www.brookings.edu/research/going-local-connecting-the-national-labs-to-their-regions-to-maximize-innovation-and-growth/

[281] Harvard Kennedy School Belfer Center, *The Department of Energy National Laboratories*. https://www.belfercenter.org/sites/default/files/files/publication/enrp-stpp-lab-report-final-1.pdf

[282] American Energy Innovation Council and Bipartisan Policy Center, *U.S. Energy R&D Architecture*. https://bipartisanpolicy.org/wp-content/uploads/2019/03/BPC-AEIC-Energy-RD-Architecture.pdf

[283] American Energy Innovation Council and Bipartisan Policy Center, *Energy Innovation: Supporting the Full Innovation Lifecycle*. https://bipartisanpolicy.org/wp-content/uploads/2020/02/AEIC_Annual-Report_2020_R01.pdf

[284] Information Technology & Innovation Foundation, *Clean Energy Start-Up Companies*. https://itif.org/publications/2020/08/24/clean-energy-start-companies-are-most-likely-succeed-when-they-partner

- Energizing America: A Roadmap to Launch a National Energy Innovation Mission (Information Technology and Innovation Foundation, 2020)[285]

***Turning the Page: Reimagining the National Laboratories in the 21st Century Innovation Economy (Information Technology and Innovation Foundation, 2013)[286]***

The authors state that "… DOE's National Laboratories have been a cornerstone of high-impact, federal funded research and development… As the United States moves deeper into the 21st century, the importance of advancing innovation becomes even more important if our nation is to thrive…While the pace of innovation and the complexity of national challenges have accelerated, the labs have not kept stride."

"The federal government must reform the labs from the 20th century atomic energy roots to create 21st century engines of innovation. The report aims to lay the groundwork for reform from their 20th century atomic-energy roots to create 21st century engines of innovation." The reports' analysis and policy recommendations fall into three major categories:

- "Transforming lab management from EOE micromanagement to contractor accountability
- Unifying lab stewardship, funding, and management stovepipes with innovation goals
- Moving technology to market with better incentives and more flexibility"

The report describes a "missing link between lab and market," and identifies a number of issues:

- Lab managers have weak incentives to work with industry
- Inconsistent lab-industry agreements
- Conflict-of-interest laws quash culture of entrepreneurship
- Lab-evaluation metrics discourage technology transfer

The report proposes recommendations to make labs better industry partners by moving technology to market with better incentives and more flexibility:

- Expand ACT agreements.
- Allow labs to use flexible pricing for user facilities and special capabilities.
- Allow labs autonomy in nonfederal funding-partnership agreements.
- Add weight to technology transfer in the expanded PEMP process.

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[285] Information Technology & Innovation Foundation, *Energizing America*. https://itif.org/publications/2020/09/15/energizing-america-roadmap-launch-national-energy-innovation-mission

[286] The Information Technology and Innovation Foundation, The Center for American Progress, and The Heritage Foundation, *Turning the Page*. http://www2.itif.org/2013-turning-the-page.pdf?_ga=2.241766658.1275738037.1605894047-1608027418.1605037154

- Execute consistent guidelines on conflict of interest.

***Going Local: Connecting the National Laboratories to their Regions for Innovation and Growth (Brookings Institution, 2014)***[287]

The report posits that DOE labs have been in the vanguard of America's global research and development leadership since the 1940's, that the national innovation system systems has changed in the past 70 years, that today much technology development and applications occurs in the context of synergistic regional clusters of firms and other organizations, and that "legacy operating procedures limit the DOE labs' ability to engage fully with the regional economies in which they are located…likely "limit[ing] the labs' overall contributions to U.S. economic growth."[288]

The report approvingly quotes Sec of Energy Ernest Moniz statement that the "National Laboratories are a leading force in driving U.S. scientific and technological innovation and advancing the Department's science, energy, environmental and national security missions."[289]

The report argues that "the nation's regional clusters are important sources of national problem-solving, innovation and prosperity," that "to date, the labs have made neither technology commercialization nor regional cluster participation a top priority," and that "as a result, they have been unable to optimally connect to the broader U.S. innovation ecosystem and deliver on their responsibility to contribute to national economic growth."

The report identifies "four problems [that] limit the impact of DOE labs on their surrounding regional economies:"

- DOE's economic strategy remains inconsistent
- Smaller firms find it difficult to work with the lab system
- Labs are not incentivized to engage regional industry clusters
- DOE and congressional micromanagement restrict labs' regional engagement[290]

Four major recommendations are proposed "Toward More Regionally Connected National Laboratories".[291] These major recommendations include specific technology transfer items:

- Improve the labs as economic assets.
    - Fully implement the Commercialization Fund and task to the OTT

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[287] Brookings, *Going Local: Connecting the National labs to their Regions to Maximize Innovation and Growth.* https://www.brookings.edu/research/going-local-connecting-the-national-labs-to-their-regions-to-maximize-innovation-and-growth/

[288] *Ibid*, page 1.

[289] Brookings, *Going Local: Connecting the National labs to their Regions to Maximize Innovation and Growth*, page 2. https://www.brookings.edu/research/going-local-connecting-the-national-labs-to-their-regions-to-maximize-innovation-and-growth/

[290] *Ibid*, pages 5-9.

[291] Brookings, *Going Local: Connecting the National labs to their Regions to Maximize Innovation and Growth*, page 9-11. https://www.brookings.edu/research/going-local-connecting-the-national-labs-to-their-regions-to-maximize-innovation-and-growth/

  - Scale best practices that currently exist within individual labs

- Open labs to SMEs
  - Create a simple, expedited lab agreement, particularly for regional firms
  - Create a National Laboratories Innovation Voucher Program

- Increase labs relevance to regional and metropolitan clusters
  - Align success metrics and lab report cards to incentivize regional engagements…lab stewards should create or elevate the technology transfer component of the PEMPs grade into the top mission category…[and] create a regional engagement target in PEMPs."

- Provide greater flexibility in terms of DOE oversight and funding
  - Allow labs to engage in nonfederal state and regional partnerships that do not require DOE approval.

The report concludes with a listing of reforms requiring DOE or Administration Action, Congressional Action, and State Government Action.[292]

***U.S. Energy R&D Architecture: Discrete Roles of Major Innovation Institutions (American Energy Innovation Council and Bipartisan Policy Center, 2019)***[293]

Notes that "While the private sector plays the dominant role in commercializing the new technologies that will reinvent the energy sector, smart federal investments should seek to address critical gaps in the innovation process." Recognizes the "recently created Office of Technology Transitions, tasked with expanding the commercial impact of DOE's research portfolio, is just one of the ways the agency is working to better align public and private sector priorities. "…this white paper will examine the differing and complementary roles played by the major innovation institutions with the energy innovation ecosystem."[294] (p.1)

<u>The National Laboratories</u>[295]

"In addition to pursuing innovative, breakthrough energy technologies, the National Laboratories have also actively developed new institutional models that an increase their efficacy. One such example [is] Cyclotron Road…"

The report notes that "funding for the National Laboratories has remained relatively flat since 1976, decreasing significantly as a percentage of our national research and development budget" (p.5) and that "Global competitors, especially in Europe and Asia, are investing heavily in innovation as a way to build their own economies."

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[292] *Ibid*, pages 13-14.
[293] American Energy Innovation Council and Bipartisan Policy Center, *U.S. Energy R&D Architecture*. https://bipartisanpolicy.org/wp-content/uploads/2019/03/BPC-AEIC-Energy-RD-Architecture.pdf
[294] *Ibid*, page 1.
[295] American Energy Innovation Council and Bipartisan Policy Center, *U.S. Energy R&D Architecture,* pages 2-6. https://bipartisanpolicy.org/wp-content/uploads/2019/03/BPC-AEIC-Energy-RD-Architecture.pdf

- ARPA-E
- Energy Frontier Research Centers (EFRCs)
- Energy Innovation HUBS
- National Network for Manufacturing Innovation (NNMIs)

***The Department of Energy National Laboratories – Organizational design and management strategies to improve federal energy innovation and technology transfer to the private sector (Harvard Kennedy School, Belfer Center, 2017)***[296]

The Report recommends policies and actions to improve the return on investment the United States government makes in sponsoring research and development at DOE's seventeen National Laboratories. The authors opine that the GoCo model is "inherently more flexible and independent than intramurally performed research" and propose a better balance between "the central role of DOE in setting lab priorities and managing the disbursement of funds" with the revision of some oversight practices "to promote a greater level of trust and independence for the Labs to execute their technical missions, which in many cases require enhancing interactions with the private sector."[297]

The Report makes "high level recommendations for Lab management policy":

- "Maintaining the essential role of the National Laboratories in executing DOE's multiple missions but restoring the original intent of the GoCo framework to allow the system to better serve its energy innovation mission.
- Creating incentives to engage a broader range of private sector research and private contractor partners to impact Lab culture and enhance the transfer of competencies directly relevant to its energy innovation mission.
- Encouraging DOE to give greater authority to Lab scientists and scientific leadership in the research decision-making process."

The high-level recommendations for technology transfer policy are:

- Providing Lab technology transfer offices with additional resources to maximize the public value of their portfolio of existing inventions by increasing private competition for commercialization partnership opportunities.
- Increase the capacity of DOE to span the boundary between Lab technologists and political management to create cross-Lab strategies for engaging the private sector.
- Adopt new practices and policies to incentivize Lab scientists and engineers to meaningfully engage with technology commercialization partners.

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[296] Harvard Kennedy School Belfer Center, *The Department of Energy National Laboratories*. https://www.belfercenter.org/sites/default/files/files/publication/enrp-stpp-lab-report-final-1.pdf
[297] *Ibid,* Executive Summary page 1.

- Develop new creative technology transfer contracting mechanisms that strengthen the incentive for commercialization partners to invest their own resources in follow-on innovation that builds on Lab inventions.

- Track and improve on metrics measuring how well Labs transfer technologies and exploit the potential of their invention stockpile"

Detailed descriptions of the technology transfer policy recommendations and metrics to assess progress are presented in the Report.[298] The authors conclude by stating that their recommendations "center on a thesis that the key to Lab management lies in the proper internal management of scientific R&D and strengthening appropriate external ties between the Labs and the private sector".

***Energy Innovation: Supporting the Full Innovation Lifecycle (American Energy Innovation Council and Bipartisan Policy Center, 2020)***[299]

The American Energy Innovation Council is a project of the Bipartisan Policy Center and has written reports on energy innovation over the years.[300]

In this most recent report, the Council posits a "growing urgency for the United States to address the critical challenges of climate change and global economic competitiveness." The report calls for a tripling of investment in the full energy lifecycle – basic science and federal institutional and financial structures to support the scale-up and demonstration of low-and zero emission energy technologies for deployment here and abroad."

The report also points to the low level of Energy R&D as a percent of GDP and the increased funding by competitors such as China. The report presents 9 recommendations:

For research and development

1. Expand ARPA-E appropriations to $1 billion/yr. (Congress)

2. Authorize and appropriate $20 million/yr. for the Lab Embedded Entrepreneurship Program. (Congress)

3. Authorize and appropriate $16 million/yr. for OTT and the head should report directly to the Secretary. (Congress)

For demonstration and deployment

4. Strengthening and enhancing DOE's loan program office. (Congress)

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[298] Harvard Kennedy School Belfer Center, *The Department of Energy National Laboratories,* pages 86-96. https://www.belfercenter.org/sites/default/files/files/publication/enrp-stpp-lab-report-final-1.pdf

[299] American Energy Innovation Council and Bipartisan Policy Center, *Energy Innovation: Supporting the Full Innovation Lifecycle*. https://bipartisanpolicy.org/wp-content/uploads/2020/02/AEIC_Annual-Report_2020_R01.pdf

[300] Examples of reports on energy innovation by the Bipartisan Policy Center include: [AEIC Scaling Innovation Project. https://bipartisanpolicy.org/report/aeic-scaling-innovation-project/; Energy Innovation: Supporting the Full Innovation Lifecycle; https://bipartisanpolicy.org/report/energy-innovation-supporting-the-full-innovation-lifecycle/; and Carbon Removal: Comparing Historical Federal Research Investments with the National Academies' Recommended Future Funding Levels. https://bipartisanpolicy.org/report/carbon-removal-comparing-historical-federal-research-investments-with-the-national-academies-recommended-future-funding-levels/]

5. Additional institutional mechanisms to support early-stage commercial projects (Congress)
6. Energy tax provisions focused on supporting deployment (Congress)
7. Innovation multipliers to incentivize innovation within energy standards
8. Public procurement programs to establish early market demand
9. Infrastructure financing designed to support innovative technologies

The report notes certain policies that are proposals that don't exist or are currently limited: including a DOE foundation, novel capital deployment mechanisms, innovative tax provisions, and public procurement policies.

***Energizing America: A Roadmap to Launch a National Energy Innovation Mission (Information Technology and Innovation Foundation, 2020)***[301]

The report calls for a National Energy Innovation Mission, making the case for a dramatic increase in funding for clean energy innovation, and providing a detailed roadmap for doing so.[302] The report amplifies and supports many of the recommendations in the BPC/AEIC report.

"Federal funding is critical to US energy innovation. Emerging clean energy technologies face steep barriers to market success. Risk-averse incumbent firms, byzantine regulations, and the inertia of existing infrastructure and subsidies built around fossil fuels can sink even the most promising ventures. RD&D investments should be paired with policies to support the market deployment and export of clean energy technologies…"

The report proposes to prioritize funding around 10 technologies and industrial sector pillars and stress six strategic principles; noteworthy in the latter are "2. Support of all stages of the innovation pipeline (also see pp. 77-81) … 3. Marshall the full capacity of the federal government (pp. 81-84)… 5.Partner with state and local governments to support regional innovation. (P.88-89) " P.4 – Figure ES-1)."

The report proposes an increase for the Mission of $25 billion by 2025, but importantly, recognizes role that other agencies contribute to clean energy technology development. In addition to DOE Office of Science, Applied Energy, and ARPA-E, this includes NASA, USDA, NSF, DOD, Other (e.g., NIST), Demonstration Projects, and International Collaboration.[303]

Of the increase proposed from 2020 to 2022 of $8.894 B to $11.758 B, DOE would receive $2.171B, and the other agencies $.672B, approximately one-quarter of the increase, but the percent increases for the all other agencies would slightly exceed that of DOE (33-31 percent).

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[301] Information Technology & Innovation Foundation, *Energizing America*. https://itif.org/publications/2020/09/15/energizing-america-roadmap-launch-national-energy-innovation-mission
[302] *Ibid,* pages 1-2.
[303] Information Technology & Innovation Foundation, *Energizing America,* page 6 figure ES-2. https://itif.org/publications/2020/09/15/energizing-america-roadmap-launch-national-energy-innovation-mission

While the focus of the report is providing additional funding for energy-related RD&D, the report acknowledges the importance of downstream deployment:[304]

“In addition to funding energy RD&D, policymakers should pursue measures to promote inclusive economic growth and clean energy technology exports in industrial clusters around the country”

“… federal investments in innovation are not guaranteed to result in globally competitive, job-creating industries located in the United States.”

“… it will be essential to promote diverse elements of innovative industrial ecosystems, such as manufacturing capabilities, local supply chains, and engineering talent…”

“… it will take public funding for demonstration, manufacturing and export finance – along with immigration, education and training policies that prepare a qualified workforce – in order to seed industrial clusters in communities across the country, promote inclusive growth, and reap the full economic benefits of energy innovation.”

The report identifies barriers to energy innovation:

“The process of energy innovation is fundamentally different from innovation in many other sectors of the economy. Clean energy companies face high up-front capital requirements and highly regulated markets…New energy technologies often take decades of development and billions of dollars of investment before achieving commercial traction.”

“Private investment alone is not sufficient to propel energy innovation at the rate needed for the United States to outcompete its rivals or bring clean energy technologies to the market fast effort to confront climate change… In 2019, less than 10 percent of private investment flows for clean energy in the United States supported innovative companies…

The VC model for investments in software or pharmaceutical does not “work[s] for the energy sector, where capital requirements are high, development timelines are long, and demonstration and de-risking opportunities are scarce”

“Although VCs shifted their bets away from clean energy solutions, a new generation of investors is emerging. Some self-dubbed “patient capital” investors are prepared to wait a decade or longer for their investments to mature and ultimately pay outsized returns.” Examples include electric power utilities and oil and gas majors, as well as companies from Microsoft to Amazon.

“In tandem with “technology-push” investments in RD&D, policymakers should also adopt “demand-pull” policies that primate commercial markets to favor the speedy deployment of the most cost-effective clean energy technologies…they are essential complements to public investments in RD&D…nationwide carbon price…standards for clean electricity, vehicles, buildings and fuels…tax incentives…public procurement…”

The report concludes with Three Immediate Recommendations:

- The president should launch a National Energy Innovation Mission

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[304] *Ibid*, pages 18, 20-25, 32, and 93.

- Congress should increase funding for energy RD&D in its FY22 budget
- The United States should reassert leadership on international energy innovation

***Collaboration Between Start-Ups and Federal Agencies: A Surprising Solution for Energy Innovation (Information Technology and Innovation Foundation, 2020)***[305]

This report analyzes the impact of collaborations between climate start-up companies and partners such as universities, other firms, and government laboratories, in terms patenting activity and private sector financing of the start-up. Based upon research reported in "Government as partners: The Role of alliances in U.S. cleantech startup innovation" (Research Policy 48 2019), this rigorous academic study was produced by scholars at UMD and two international institutions. The authors compiled a novel database of 657 U.S. clean tech start-ups (< 5 years between 2008-2012) and 2,015 alliances with governments, firms, research organizations and not-for-profit, and found that "Start-up patenting activity soars by an average of 74 percent as a result of collaborating with a government agency or laboratory, while each technology license given out by a government agency to a start-up more than doubles its financial deals."[306]

The report analyzes "start-up activity," not "spin-outs" from federal labs and agencies; of the 657 start-ups they included in their database, 43 conducted collaborations with government, 50 with universities, and 243 with other firms. In a network chart presented in the Research Policy paper, governmental partners are identified as NREL, Sandia, ORNL, PNNL, LBNL, DOE, the US Army, NASA, DOD and the U.S. Navy.[307] The authors comment that "licensing technologies to start-ups is infrequent."[308]

The authors identify a "lack of resources" as a challenge to all start-ups, but particularly in clean energy innovation, because the VC model, "built around short-term, quick returns, was designed primarily for information technology (IT) companies," and "…patient investors such as Breakthrough Energy Ventures…are scattered," but that "collaboration with external partners provides climate-tech start-ups with resources and tangible assets that help them navigate through the valley of death and get the investment they need."[309]

The authors find a "…Surprising Solution: Government Agencies Make Better Partners".[310]

The authors identify "three fundamental barriers that need to be overcome to fully reap the benefits from federal government and start-up collaborations": lack of networks and knowledge

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[305] Information Technology & Innovation Foundation, *Clean Energy Start-Up Companies*.
https://itif.org/publications/2020/08/24/clean-energy-start-companies-are-most-likely-succeed-when-they-partner
[306] *Ibid*, page 1.
[307] Information Technology & Innovation Foundation, *Clean Energy Start-Up Companies,* page 146.
https://itif.org/publications/2020/08/24/clean-energy-start-companies-are-most-likely-succeed-when-they-partner
[308] *Ibid*, page 10.
[309] Information Technology & Innovation Foundation, *Clean Energy Start-Up Companies,* page 5.
https://itif.org/publications/2020/08/24/clean-energy-start-companies-are-most-likely-succeed-when-they-partner
[310] *Ibid*, page 6.

and bureaucratic barriers and high costs; weak incentives for federal agencies to work with start-up; and lack of coordination within DOE and the labs and across other agencies.[311]

The authors propose a set of recommendations to address the three barriers and "help improve start-up access to federal experts, infrastructure and patented technologies."

"Scale-up mechanisms for start-ups to collaborate with federal agencies and laboratories," including partnerships with incubators, funding for federal lab-linked incubator programs, communications and convenings, extension and expansion of the SBV program, and waiver of fees for start-up licenses.

"Incentivize federal agencies and laboratories to work with start-ups," including authorize funding for lab tech transfer offices (not part of overhead), entrepreneurial-leave programs, Energy I-Corps, and incorporation of technology transfer metrics in PEMPs that "capture collaboration with start-ups."

"Improve coordination between federal agencies, laboratories and other entities in support of climate-tech start-ups," including an NSTC led interagency effort to develop a repository of collaboration opportunities across major federal R&D agencies, engagement by tech transfer offices with stakeholders in regional innovations ecosystems, and establishment of a nonprofit Energy Technology Commercialization Foundation, "catalyzing its connections with DOE, entrepreneurs, regional partners and incubators…[to] foster collaborations among start-ups and federal entities."[312]

[311] Information Technology & Innovation Foundation, *Clean Energy Start-Up Companies,* page 13.
https://itif.org/publications/2020/08/24/clean-energy-start-companies-are-most-likely-succeed-when-they-partner
[312] *Ibid*, pages 14-15.

## DOE Advanced Manufacturing Institutes[313]

### *Power America: The Next Generation Power Electronics Manufacturing Innovation Institute*

**Mission:** The Power America institute at North Carolina State University seeks to save energy and create U.S. manufacturing jobs by accelerating the development and large-scale adoption of wide-bandgap semiconductor technology in power electronic systems.

**Headquarters:** Raleigh, NC

**Established:** January 2015

**Consortium Organizer:** North Carolina State University

**Funding:** Federal, $70M; Nonfederal, $70M; both planned over five years

**Members (as of September 30, 2018):** 48

### *iACMi: Institute for Advanced Composites Manufacturing Innovation*

**Mission:** Create an ecosystem of innovation to drive commercial outcomes leading to economic growth in the advanced-composites field.

**Headquarters:** Knoxville, TN

**Satellite Locations:** IACMI Scale-up Research Facility (SURF) (Detroit, MI); Michigan State University Composites Lab (Lansing, MI); University of Dayton Research Institute's Composites Laboratory (Dayton, OH); The Composites Manufacturing Education and Technology Facility (CoMET) at the National Renewable Energy Laboratory's National Wind Technology Center (Boulder, CO); The Indiana Manufacturing Institute at Purdue University (West Lafayette, IN); The University of Tennessee's Fibers and Composites Manufacturing Facility (Knoxville, TN); Oak Ridge National Laboratory (Oak Ridge, TN); Vanderbilt University's Laboratory for Systems Integrity and Reliability (LASIR) (Nashville, TN)

**Established:** June 2015

**Consortium Organizer:** Collaborative Composite Solutions Corporation, a not-for-profit corporation under the University of Tennessee Research Foundation

**Funding:** Federal, $70M; Nonfederal, $178M; both planned over five years

**Members (as of February 28, 2019):** 154

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[313] United States National Institute of Standards and Technology, *Annual Report 2018, Manufacturing USA,* pages 68-87. https://nvlpubs.nist.gov/nistpubs/ams/NIST.AMS.600-5.pdf

***CESMii: Clean Energy Smart Manufacturing Innovation Institute***

**Mission:** To accelerate development and adoption of advanced sensors, controls, platforms, and models to enable smart manufacturing to become the driving, sustainable engine that delivers real-time business improvements in U.S. manufacturing.

**Headquarters:** Los Angeles, CA

**Regional Manufacturing Centers:**

Western — University of California at Los Angeles Northern — Rensselaer Polytechnic Institute (Troy, NY) Southern — Texas A&M University (College Station, TX)

Southern Satellite — North Carolina State University (Raleigh, NC)

**Established:** January 2017

**Consortium Organizer:** University of California at Los Angeles

**Funding:** Federal, $70M; Nonfederal, $70M; both planned over five years

**Members (as of September 30, 2018):** 102

***RAPiD: Rapid Advancement in Process Intensification Deployment Institute***

**Mission:** Advance modular chemical process intensification (MCPI) technologies to reduce energy consumption, improve process efficiencies, and reduce investment and operating requirements.

**Headquarters:** New York, NY

**Established:** March 2017

**Consortium Organizer:** American Institute of Chemical Engineers (AIChE)

**Funding:** Federal, $70M; Nonfederal, $70M; both planned over five years

**Members (as of September 30, 2018):** 70

**REMADE: Reducing EMbodied-energy And Decreasing Emissions**

**Mission:** Advance modular chemical process intensification (MCPI) technologies to reduce energy consumption, improve process efficiencies, and reduce investment and operating requirements.

**Headquarters:** Rochester, NY

**Established:** May 2017

**Consortium Organizer:** Sustainable Manufacturing Innovation Alliance

**Funding:** Federal, $70M; Nonfederal, $70M; both planned over five years

**Members (as of September 30, 2018):** 75

**CyManll – Cyber Security Manufacturing Innovation Institute**

**Announced:** May 2020

**Consortium Organizer:** University of Texas, San Antonio

**Funding:** The Institute will leverage up to $70 million, over 5 years, in federal funding, subject to appropriations, and will be matched by over $40 million in private-cost share commitments.

<u>**DOE Obligations for Research and Development**</u>

## Figure I.4: Federal Obligations for Research and Development, by Agency and Performer: FY 2018

### (Dollars in millions)

*Source: The National Science Foundation.*

| Agency | Total R&D | Intramural | | | | Extramural | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | United States and U.S. territories | | | | Foreign |
| | | Intramural[a] | Industry-administered FFRDCs | University-administered FFRDCs | Nonprofit-administered FFRDCs | Industry | Universities and colleges | Other nonprofits | State, local governments | |
| **Department of Energy** | 12,832.4 | 1,336.0 | 3,058.1 | 2,222.7 | 2,220.7 | 2,375.1 | 1,350.1 | 199.1 | 69.0 | 1.5 |
| **Advanced Research Projects Agency—Energy** | 159.9 | 0.0 | 5.6 | 1.5 | 10.9 | 46.3 | 83.4 | 12.2 | 0.0 | 0.0 |
| **Electricity Delivery and Energy Reliability** | 145.8 | 3.8 | 16.8 | 16.0 | 50.3 | 15.8 | 17.3 | 25.4 | 0.5 | 0.0 |
| **Energy Efficiency and Renewable Energy** | 1,686.3 | 0.0 | 133.4 | 200.2 | 656.4 | 387.5 | 262.4 | 0.0 | 46.4 | 0.0 |
| **Environmental Management** | 38.0 | 0.4 | 10.2 | 0.5 | 3.4 | 5.9 | 17.6 | 0.0 | 0.0 | 0.0 |
| **Fossil Energy** | 661.6 | 193.6 | 92.7 | 14.5 | 18.9 | 128.1 | 103.2 | 88.5 | 22.1 | 0.0 |
| **National Nuclear Security Administration** | 4,057.4 | 342.6 | 2,328.0 | 16.1 | 54.6 | 1,265.1 | 13.5 | 37.6 | 0.1 | 0.0 |

| Agency | Total R&D | Intramural | | | | Extramural | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | United States and U.S. territories | | | | Foreign |
| | | Intramural[a] | Industry-administered FFRDCs | University-administered FFRDCs | Nonprofit-administered FFRDCs | Industry | Universities and colleges | Other nonprofits | State, local governments | |
| **Defense Programs** | 2,572.0 | 287.1 | 2,081.3 | 4.9 | 3.4 | 155.5 | 2.2 | 37.6 | 0.0 | 0.0 |
| **Naval Nuclear Propulsion Program** | 1,205.8 | 54.9 | 76.5 | 0.1 | 0.0 | 1,074.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Office of Defense Nuclear Nonproliferation** | 279.5 | 0.6 | 170.3 | 11.1 | 51.1 | 35.1 | 11.2 | 0.0 | 0.1 | 0.0 |
| **Nuclear Energy** | 1,115.6 | 526.9 | 259.6 | 41.8 | 99.7 | 134.4 | 52.3 | 0.0 | 0.0 | 0.9 |
| **Office of Science** | 4,967.7 | 268.7 | 211.8 | 1,932.2 | 1,326.7 | 392.0 | 800.3 | 35.3 | 0.0 | 0.6 |

* = amount greater than $0 but less than $50,000.

FFRDC = federally funded research and development center.

Intramural activities cover costs associated with the administration of intramural R&D programs and extramural R&D procurements by federal personnel as well as actual intramural performance.

NOTES: Because of rounding, detail may not add to total. Only those agencies and subdivisions that had obligations in variables represented by this table appear in the table. See technical table A-2 for additional notes associated with the agencies listed in this table.

SOURCE: National Center for Science and Engineering Statistics, Survey of Federal Funds for Research and Development, FYs 2018–19.

## Selected Agency Technology Transfer Metrics[314]

**Figure I.5: Selected Agency Technology Transfer Metrics for FY 2016***

***All Dollars in Millions**

### Total Federal Obligations for R&D

| | | |
|---|---|---|
| DoD | $44,749 | 39% |
| HHS | $32,216 | 28% |
| NASA | $12,404 | 11% |
| DOE | $11,601 | 10% |
| USDA | $2,358 | 2% |
| **Selection Total** | **$103,328** | **90%** |
| **All Agencies** | **$115,042** | **100%** |

### Total Intramural and FFRDC Obligations for R&D

| | | |
|---|---|---|
| DoD | $18,567 | 43% |
| DOE | $8,152 | 19% |
| HHS | $7,643 | 18% |
| NASA | $3,314 | 8% |
| USDA | $1,538 | 4% |
| **Selection Total** | **$39,214** | **90%** |
| **All Agencies** | **$43,421** | **100%** |

[314] United States National Institute of Standards and Technology, *Federal Laboratory Technology Transfer Fiscal Year 2016*. https://www.nist.gov/system/files/documents/2019/10/30/fy2016_fed_lab_tech_transfer_rept_fina_9-10-19.pdf

**Intramural & FFRDCs as % of Total R&D Budget**

| | |
|---|---|
| DOE | 70% |
| USDA | 65% |
| NASA | 27% |
| DoD | 41% |
| HHS | 24% |

**New Invention Disclosures**

| | | |
|---|---|---|
| DOE | 1760 | 35% |
| NASA | 1554 | 31% |
| DoD | 874 | 17% |
| HHS | 320 | 6% |
| USDA | 244 | 5% |
| **Selection Total** | **4752** | **93%** |
| **All Agencies** | **5086** | **100%** |

**Patent Applications**

| | | |
|---|---|---|
| DOE | 999 | 38% |
| DoD | 941 | 36% |
| HHS | 269 | 10% |

| | | |
|---|---|---|
| NASA | 129 | 5% |
| USDA | 109 | 4% |
| **Selection Total** | **2447** | **94%** |
| **All Agencies** | **2596** | **100%** |

**Patents Issued**

| | | |
|---|---|---|
| DOE | 856 | 37% |
| DoD | 665 | 28% |
| HHS | 579 | 25% |
| NASA | 103 | 4% |
| USDA | 60 | 3% |
| **Selection Total** | **2263** | **97%** |
| **All Agencies** | **2341** | **100%** |

**Active Licenses**

| | | |
|---|---|---|
| DOE | 5410 | 60% |
| HHS | 1750 | 20% |
| DoD | 515 | 6% |
| NASA | 452 | 5% |
| USDA | 441 | 5% |

| | | |
|---|---|---|
| **Selection Total** | **8568** | **96%** |
| **All Agencies** | **8950** | **100%** |

**Invention Licenses**

| | | |
|---|---|---|
| HHS | 1721 | 41% |
| DOE | 943 | 23% |
| NASA | 387 | 9% |
| USDA | 370 | 9% |
| DoD | 358 | 9% |
| **Selection Total** | **3779** | **91%** |
| **All Agencies** | **4156** | **100%** |

**Income Bearing Licenses**

| | | |
|---|---|---|
| DOE | 3963 | 68% |
| HHS | 837 | 14% |
| USDA | 439 | 8% |
| NASA | 245 | 4% |
| DoD | 194 | 3% |
| **Selection Total** | **5678** | **98%** |
| **All Agencies** | **5804** | **100%** |

**Active Licenses to Small Businesses & As Percentage of All Active Licenses**

| | | |
|---|---|---|
| DOE | 255 | 5% |
| NASA | 243 | 54% |
| USDA | 152 | 34% |
| HHS | 112 | 6% |
| DoD | N/A | N/A |
| **Selection Total** | **762** | **95%** |
| **All Agencies** | **798** | **100%** |

**Total Active CRADAs, CRADAs Involving Small Businesses, Small Businesses as a Percentage of Total Active CRADAs**

| | | | |
|---|---|---|---|
| DoD | 3125 | 351 | 27% |
| DOE | 739 | 282 | 22% |
| HHS | 590 | 252 | 20% |
| USDA | 238 | 76 | 6% |
| NASA | 12 | 0 | 0% |
| **Selection Total** | **4704** | **961** | **75%** |
| **All Agencies** | **11644** | **1281** | **100%** |

## DOE Commercialization Initiatives

**Figure I.6: NSTC's List of Tech Transfer Initiatives**

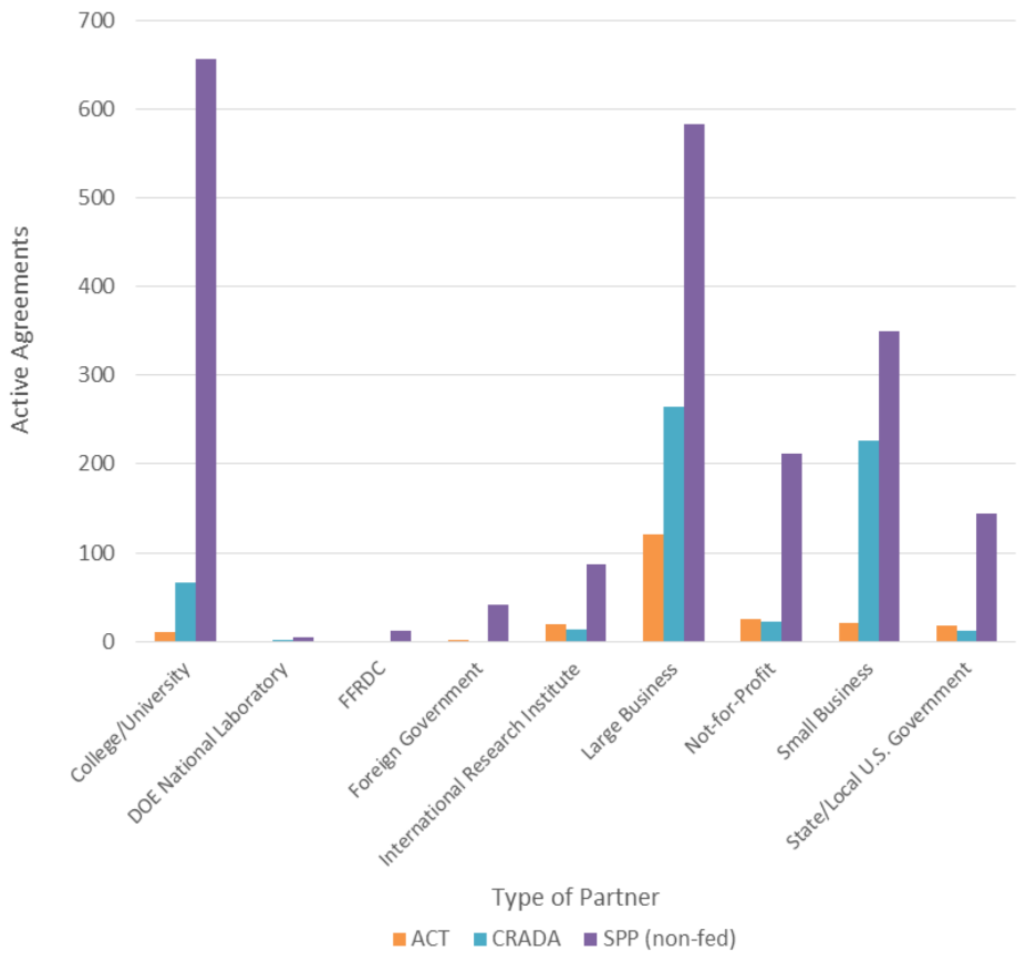
| Title of Program/Initiative/Activity<br>*Source: National Science and Technology Council, Lab-to-Market Subcommittee (2018)* | |
|---|---|
| 1 | Accelerator Stewardship Program |
| 2 | DOE's National Incubator Initiative for Clean Energy (NIICE) |
| 3 | Engagement with early-stage technology institutional investors (e.g., the IP Group) |
| 4 | Illinois Accelerator Research Center (IARC) |
| 5 | NREL - Wells Fargo Innovation Incubator (IN2) |
| 6 | Technologist in Residence Program |
| 7 | Streamlined Technical Services Strategic Partnership Projects (SPPs) |
| 8 | Idea-EZ Form |
| 9 | Agreement for Commercializing Technology (ACT) |
| 10 | Software Language in Subcontracts |
| 11 | Agile Bio Foundry |
| 12 | Annual Lab Pitch Competition |
| 13 | Argonne Collaborative Center for Energy Storage Science (ACCESS) |
| 14 | Argonne Commercialization Council |
| 15 | CalCharge Consortium |
| 16 | Center for Collaboration and Commercialization (C3) |
| 17 | DOE National Laboratories Collaborative Startup Challenge |
| 18 | DOE/OTT Energy Investor Center (EIC) Ongoing Partnership Development |
| 19 | Energy Materials Network |
| 20 | Gateway for Accelerated Innovation in Nuclear (GAIN) |
| 21 | HPC for Manufacturing (HPC4Mfg) and HPC for Materials (HPC4Materials) programs |
| 22 | Joint BioEnergy Institute (JBEI) |
| 23 | Joint Center for Energy Storage Research (JCESR) |
| 24 | National Security Programs |
| 25 | PHENIX Industry Consortium |
| 26 | Sandia Science & Technology Park |
| 27 | AIM On Shore/Build4Scale Manufacturing Training for Cleantech Entrepreneurs |
| 28 | Argonne Commercialization Excellence Awards |
| 29 | Cleantech to Market (C2M) |
| 30 | Consolidated Nuclear Security LLC's Internal Technology Fellow Program |
| 31 | DOE's Clean Technology University Prize Competition (Cleantech Up) |
| 32 | Entrepreneur Exploration (EEx) |
| 33 | Entrepreneurial Separation to Transfer Technology |
| 34 | Entrepreneur-in-Residence |
| 35 | Jefferson Lab Entrepreneurial Leave Program |
| 36 | Launchpad Program |
| 37 | League of Ingenuity (Employee Recognition Program) |

| | |
|---|---|
| 38 | Outside Consulting Program |
| 39 | DisrupTECH |
| 40 | DOE/OTT Energy Investor Center (EIC) Laboratory-Investor Knowledge Series (LINKS) |
| 41 | Intellectual Property at the Federal Labs Seminar |
| 42 | NREL Industry Growth Forum |
| 43 | Program Development Workshop Series |
| 44 | Technology & Market Discovery Webinars |
| 45 | Technology Transfer Workshop at Jefferson Lab |
| 46 | America's Next Top Energy Innovator |
| 47 | Berkeley Lab IPO Innovation Grants |
| 48 | DOE’s Small Business Voucher Pilot (SBV) |
| 49 | NREL Accelerating Inventions to Market (AIM) Program |
| 50 | Start-Up Xpress Terms License |
| 51 | Technology Commercialization Fund (TCF) |
| 52 | Tennessee RevV! Voucher Program |
| 53 | UC/Los Alamos Entrepreneurial Postdoctoral Fellowship |
| 54 | CRADA Strategy Development & Implementation |
| 55 | Small Business Innovation Research (SBIR) Technology Transfer Opportunity |
| 56 | Technology Maturation Program |
| 57 | Use of Royalty Funds to accelerate the post-contract initiation of work |
| 58 | Energy I-Corps, formerly DOE’s Lab-Corp Pilot |
| 59 | Berkeley Lab Innovation Corps (BLIC) |
| 60 | Creative Space (C-Space) |
| 61 | Investor Outreach |
| 62 | NYSTEC Collaboration |
| 63 | Optimizing No- and Low-Cost resources to raise profile of Jefferson Lab Technology Transfer |
| 64 | ORNL Technology Innovation Program (TIP) |
| 65 | Cryo-EM Initiative at SLAC |
| 66 | Eureka Collaborative Consortium |
| 67 | Livermore Valley Open Campus (LVOC) and Advanced Manufacturing Laboratory (AML) |
| 68 | New Mexico Small Business Assistance Program |
| 69 | Volta Concept |
| 70 | Brookhaven’s Lab Innovator (L'Innovator) |
| 71 | IP Bundling Project |
| 72 | Lab-Bridge IP Bundling Project |
| 73 | DOE Support of Legal Action Against Infringement of Lab Patent |
| 74 | Berkeley Lab Marketplace |
| 75 | Advanced Biofuels and Bioproducts Process Development Unit (ABPDU) |
| 76 | Berkeley Lab IPO Innovation Portal |
| 77 | Energy Innovation Portal |

| | |
|---|---|
| 78 | Intellectual Property Marketing |
| 79 | Lab Partnering Service |
| 80 | DOE National Clean Energy Business Plan Competition |
| 81 | Technology-to-Market at ARPA-E |
| 82 | Lab-Embedded Entrepreneurship Program |
| 83 | National Lab Accelerator Program |
| 84 | National Lab Entrepreneurial Academy |
| 85 | PPPL Entrepreneurship Lunch and Learn Series |

## DOE Agreements to Commercialize Technology

**Figure I.7: DOE Agreements to Commercialize Technology**




**Technology Transfer Partners with Active Agreements across Participating Pilot Laboratories by Mechanism, FY 2014–2016**

*Source: United States Department of Energy, Presentation at the November 2017 FLC Mid Atlantic Regional Meeting on Agreements for Commercializing Technology.* https://federallabs.org/regions/mid-atlantic/events/proceedings/agreements-for-commercializing-technology-act

## National Laboratory Metrics, Sites and Plants

**Figure I.8: Selected Utilization Metrics (FY 2018)[315]**

| Total CRADAs | Total CRADAs with Small Businesses |
|---|---|
| Total | Total |
| 979 | 434 |

| Total Active Licenses | Total Licenses Granted to Small Businesses |
|---|---|
| Total | Total |
| 4742 | 169 |

| Strategic Partnership Projects | |
|---|---|
| Total Agreements | Total Agreements with Small Business Sponsors |
| 2246 | 485 |

[315] From communications with the U.S. Department of Energy Office of Technology Transitions in September 2020.

| User Facility Data: Projects | | |
|---|---|---|
| User Projects Awarded | User Projects Awarded to Small Businesses | User Projects Awarded to Industry |
| 16209 | 189 | 298 |

| Science Education Activities Performed | | |
|---|---|---|
| Undergraduate Interns | Graduate Students | Post-Doctoral Appointees |
| 4845 | 6560 | 3418 |

| Other Data Elements | | |
|---|---|---|
| Total Number of Unique Small Businesses Collaborating with the Labs | Startup Companies | Number of Active Material Transfer Agreements |
| 1218 | 17 | 1715 |

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