



February 2021

DEPARTMENT OF ENERGY

Improved Performance Planning Could Strengthen Technology Transfer



A Century of Non-Partisan Fact-Based Work

GAO@100 Highlights

Highlights of [GAO-21-202](#), a report to the Honorable Joseph Manchin, U.S. Senate

Why GAO Did This Study

Researchers at DOE and its 17 national labs regularly make contributions to new energy technologies, such as more efficient batteries for electric vehicles. Technology transfer officials at the labs help these researchers license intellectual property and partner with private-sector companies to bring these technologies to market. However, several recent reports have highlighted barriers and inconsistencies in technology transfer at DOE, including a 2015 commission report that found barriers related to the costs of collaboration and low maturity level of many DOE technologies.

This report examines (1) steps DOE has taken to address barriers to technology transfer and (2) the extent to which DOE plans and tracks the performance of its technology transfer and commercialization activities. GAO analyzed DOE documents on technology transfer and spoke with officials at DOE and seven national labs, as well as with representatives of universities and private-sector companies. GAO selected labs across a range of DOE activities and based on their technology transfer activities.

What GAO Recommends

GAO recommends that DOE assess researchers' needs for commercialization training and develop objective, quantifiable, and measurable performance goals and a limited number of related performance measures for its technology transfer efforts. DOE concurred with the recommendations.

View [GAO-21-202](#). For more information, contact Candice Wright at (202) 512-6888 or WrightC@gao.gov.

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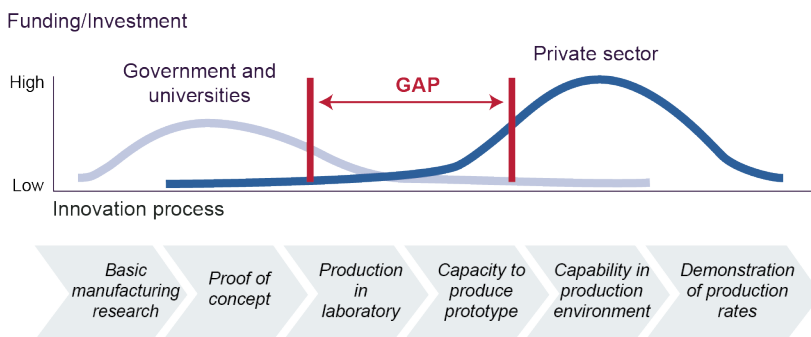
DEPARTMENT OF ENERGY

Improved Performance Planning Could Strengthen Technology Transfer

What GAO Found

The Department of Energy (DOE) and its national labs have taken several steps to address potential barriers to technology transfer—the process of providing DOE technologies, knowledge, or expertise to other entities. GAO characterized these barriers as (1) gaps in funding, (2) legal and administrative barriers, and (3) lack of alignment between DOE research and industry needs. For example, the “valley of death” is a gap between the end of public funding and start of private-sector funding. DOE partly addresses this gap with its Technology Commercialization Fund, which provides grants of \$100,000 to \$1.5 million to DOE researchers to advance promising technologies with private-sector partners. Further, DOE’s Energy I-Corps program trains researchers to commercialize new technologies and to identify industry needs and potential customers. However, DOE has not assessed how many and which types of researchers would benefit from such training. Without doing so, DOE will not have the information needed to ensure its training resources target the researchers who would benefit most.

Illustration of Funding Gap for Commercializing New Technologies



Source: GAO adapted from Executive Office of the President. | GAO-21-202

DOE plans and tracks the performance of its technology transfer activities by setting strategic goals and objectives and annually collecting department-wide technology transfer measures, such as the number of patented inventions and licenses. However, the department does not have objective and measurable performance goals to assess progress toward the broader strategic goals and objectives it developed. For example, without a performance goal for the number of DOE researchers involved in technology transfer activities and a measure of such involvement, DOE cannot assess the extent to which it has met its objective to encourage national laboratory personnel to pursue technology transfer activities. Internal control standards for government agencies call for management to define objectives in measurable terms, either qualitative or quantitative, so that performance toward those objectives can be assessed. Moreover, DOE has not aligned the 79 existing measures that it collects with its goals and objectives, nor has it prioritized them. Some lab stakeholders said that collecting and reporting these measures is burdensome. Prior GAO work has found that having a large number of performance measures may risk creating a confusing excess of data that will obscure rather than clarify performance issues.

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Abbreviations

AUTM	Association of University Technology Managers, Inc.
ARPA-E	Advanced Research Projects Agency–Energy
COVID-19	Coronavirus Disease 2019
CRADA	cooperative research and development agreement
CTAP	COVID-19 Technical Assistance Program
DOE	Department of Energy
EERE	Office of Energy Efficiency and Renewable Energy
FORGE	Frontier Observatory for Research in Geothermal Energy
GAIN	Gateway for Accelerated Innovations in Nuclear
INL	Idaho National Laboratory
NETL	National Energy Technology Laboratory
NNSA	National Nuclear Security Administration
NREL	National Renewable Energy Laboratory
OTT	Office of Technology Transitions
R&D	research and development
TCF	Technology Commercialization Fund

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February 1, 2021

The Honorable Joseph Manchin
United States Senate

Dear Senator Manchin:

The development of new energy technologies and other innovations from the Department of Energy's (DOE) national labs and other facilities can lead to the creation of new companies, new jobs, and new or better products. For example, researchers at Argonne National Laboratory developed a type of lithium-ion battery now found in some hybrid and electric cars. Similarly, in the 1990s, researchers at DOE's Ames Laboratory and Sandia National Laboratories developed a safer alternative to lead solder. Today, this technology is used in electronics assembly across the world.

In fiscal year 2017, DOE researchers received more than 800 patents for new technologies, and DOE provided more than 3,000 licenses to companies or other recipients to use technologies developed at the department. The department and national labs also help to develop technologies first conceived in the private sector by providing access to unique equipment and expertise. These examples of moving technologies, knowledge, or expertise from one person or entity to another are known as technology transfer.

However, several reports have highlighted challenges or inconsistencies with technology transfer at the department. In 2020, a DOE advisory board made preliminary recommendations to enhance the department's innovative culture and ensure that its innovations meet the ideals of solving real-world problems and being economically feasible, socially acceptable, and worth the effort to change.¹ In 2015, the statutorily created Commission to Review the Effectiveness of the National Energy Labs found that technology transfer was inconsistent across the laboratories and DOE program offices and that barriers to partnerships, such as complex contract terms and long negotiation and approval times,

¹Secretary of Energy Advisory Board, *SEAB Innovation Working Group Initial Findings*, (Washington, D.C.: April 2020).

could be significant.² Similarly, in 2009 we identified challenges to technology transfer at DOE labs, including employees' lack of time for or interest in technology transfer activities, lack of expertise in these activities, and lack of funding to demonstrate new technologies.³

In 2015, DOE established the Office of Technology Transitions (OTT) to, among other things, oversee technology transfer and commercialization activities and coordinate efforts across departmental programs, including the National Nuclear Security Administration (NNSA), which is a semi-autonomous agency within the department. OTT's mission is to expand the public impact of the department's research and development (R&D) portfolio to advance the economic, energy, and national security interests of the nation. DOE's goals for technology transfer and commercialization activities are to increase the return on DOE investments through the transition of national laboratory-developed technologies into the private sector and increase the commercial impact of DOE investments through private-sector use of national laboratory facilities and expertise.⁴

You asked us to review issues related to technology transfer at DOE and its national labs. This report examines (1) steps DOE has taken to address barriers to technology transfer and commercialization and (2) the extent to which DOE has established goals and related measures to assess the performance of its current technology transfer and commercialization activities.

To examine the steps DOE has taken and the barriers it faces, we reviewed agency and contractor documents related to technology transfer and interviewed federal officials and representatives from selected government- and contractor-operated laboratories and sites. We selected seven DOE components, including OTT, NNSA, and five out of the 12

²Department of Energy, *Securing America's Future: Realizing the Potential of the Department of Energy's National Laboratories: Final Report of the Commission to Review the Effectiveness of the National Energy Laboratories* (Washington, D.C.: Oct. 28, 2015). The Secretary established the Commission in accordance with section 319 of the Consolidated Appropriations Act of 2014. Pub. L. No. 113-76, div. D, tit. III, § 319, 128 Stat. 5, 178 (2014).

³GAO, *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](#) (Washington, D.C.: June 16, 2009).

⁴Department of Energy, *Technology Transfer Execution Plan 2016-2018*, (Washington, D.C.: 2016).

program offices. We selected the five program offices with the largest fiscal year 2020 enacted funding. Within most of the selected components, we selected one or two laboratories or sites based on OTT documentation that identified technology transfer activities at the department and national labs in 2019.⁵ The components, laboratories, and sites we selected are listed in table 1.

Table 1: Department of Energy Components, Laboratories, and Sites Included in GAO’s Review

Selected component	Selected laboratories or sites
Office of Technology Transitions (OTT)	n/a
National Nuclear Security Administration	Sandia National Laboratories Kansas City National Security Campus
Office of Science	Argonne National Laboratory Lawrence Berkeley National Laboratory
Office of Energy Efficiency and Renewable Energy (EERE)	National Renewable Energy Laboratory
Office of Nuclear Energy	Idaho National Laboratory
Office of Fossil Energy	National Energy Technology Laboratory
Advanced Research Projects Agency – Energy (ARPA-E)	n/a

Source: GAO analysis. | GAO-21-202

Note: n/a = not applicable.

We conducted 50 semi-structured interviews with federal officials, technology transfer professionals, or researchers at the seven selected DOE components and seven selected laboratories and sites.⁶ We also conducted background research and interviewed 20 representatives from 11 universities, nonprofit institutions, and companies, as well as an academic researcher and two former DOE officials, to describe potential barriers. We selected these organizations based on our background

⁵OTT and ARPA-E do not directly oversee any laboratories or sites.

⁶A semi-structured interview methodology generally involves asking a similar or standardized set of interview questions of multiple interviewees as a way to collect comparable information. We used a semi-structured interview format with open-ended questions to engage in a conversation about the topics discussed, including common aspects or factors to successful and unsuccessful technology transfer efforts and measures used to gauge commercial impact.

research and our evaluation of a 2018 request for information on federal laboratory technology transfer.⁷

To examine the extent to which DOE plans and tracks the performance of its current technology transfer and commercialization activities, we reviewed DOE performance documentation, including the department's most recent strategic plan, technology transfer execution plan, and technology transfer utilization reports. We determined that the risk assessment component of internal control—the actions management takes to assess the risks facing the entity as it seeks to achieve its objectives—was significant to the objective, along with the related principle that management should define objectives clearly to enable the identification of risks and define risk tolerances. We compared DOE's performance documents and information from our interviews to our internal control standards and to selected key practices for planning and evaluating performance from our prior work.⁸ Additional information on our scope and methodology is included in appendix I.

We conducted this performance audit from October 2019 to January 2021 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

This section discusses the organization of DOE, several mechanisms for technology transfer, and some of the challenges associated with technology transfer.

DOE Components Pursuing Technology Transfer

DOE components that have a role in technology transfer include:

⁷Department of Commerce, National Institute of Standards and Technology, "Request for Information Regarding Federal Technology Transfer Authorities and Processes." 83 Fed. Reg. 19,052 (May 1, 2018).

⁸GAO, *Standards for Internal Control in the Federal Government*, [GAO-14-704G](#) (Washington, D.C.: Sept. 10, 2014), *Managing For Results: Enhancing Agency Use of Performance Information for Management Decision Making*, [GAO-05-927](#) (Washington, D.C.: Sept. 9, 2005), and *Executive Guide Effectively Implementing the Government Performance and Results Act*, [GAO/GGD-96-118](#) (Washington, D.C.: June 1996).

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- **Program offices**, such as the Offices of Science, Nuclear Energy, Fossil Energy, Energy Efficiency and Renewable Energy (EERE), and Environmental Management, that manage research and development programs and oversee DOE national laboratories.
 - **ARPA-E**, an agency within DOE that advances high-potential, high-impact energy technologies that are too early for private-sector investment.⁹
 - **NNSA**, a separately organized agency within DOE that is responsible for maintaining and securing the U.S. nuclear weapons stockpile and preventing nuclear weapons proliferation. It also oversees certain national laboratories and other national security sites and manufacturing plants. The Office of Strategic Partnership Programs oversees technology transfer activities for the NNSA.
 - **OTT**, which is responsible for developing DOE's strategic vision and goals for technology transfer and overseeing the department's engagement with business and industry sectors.

DOE funds R&D carried out by national laboratories, plants and sites, universities, industry, nonprofit organizations, state governments, and other federal laboratories. DOE's national laboratories, plants, and sites house unique scientific equipment and expertise developed since World War II and the Manhattan Project.

Sixteen of DOE's 17 national laboratories are government-owned, contractor-operated, meaning that the department funds the labs, but third-party contractors manage them and employ the staff and researchers. One national lab, the National Energy Technology Laboratory (NETL), is a government-owned, government-operated lab, meaning that the department manages the lab, its research, and its federal researchers.

Each national lab has at least one office responsible for technology transfer activities.¹⁰ These offices are funded by DOE through indirect costs and may also have additional revenue available to them from licensing lab-developed technologies. DOE's contracts with contractor-

⁹ARPA-E was established in August 2007 by the America COMPETES Act. Pub. L. No. 110-69, § 5012, 121 Stat. 572, 621 (2007) (codified as amended at 42 U.S.C. § 16538). The act granted special authorities to ARPA-E for budget, hiring, and management that the DOE program offices do not have.

¹⁰15 U.S.C. § 3710(b).

operated national labs obligate the contractors to distribute a percentage of royalties from their licenses to inventors, and the remainder for scientific research, development, technology transfer, and education.¹¹ The program offices and NNSA annually develop Performance Evaluation and Measurement Plans that are used to evaluate contractor performance and outline priorities for the labs. Among other things, the plans define objectives for the labs and how their performance will affect any performance fee paid to the lab contractor.¹²

Technology Transfer and Commercialization Mechanisms

Technology transfer can mean moving federally developed technologies (including those developed by contractors) from DOE and its labs to the private sector, other federal agencies, and state and local governments. It can also mean providing private-sector access to department facilities and expertise. The department, national labs, and private sector have a variety of mechanisms available for technology transfer, including some that involve active partnership between researchers and either the private sector or other outside entities:

- **Technology licensing.** Businesses can obtain a license to use federal technologies, such as patented inventions, in order to integrate them into their products.¹³
- **Cooperative research and development agreements (CRADA).** Under a CRADA, federal labs collaborate with nonfederal partners to carry out research projects that will directly benefit lab missions and the partners' R&D goals. A lab may contribute personnel, equipment, or other resources to a project, while its CRADA partners may contribute funds, resources, or both.

¹¹48 C.F.R. § 970.5227-3(h) (Disposition of Income).

¹²National laboratories' performance against this plan, including a determination of fee, is reported in annual Performance Evaluation Reports.

¹³DOE has procedures for researchers to follow when developing new technologies. When researchers at national labs, plants, or sites first create new inventions that may be useful to others, they are to disclose those inventions to their technology transfer offices. Technology transfer officials then review the disclosures and decide whether to pursue a patent, copyright, or other commercialization mechanism based on commercialization and patentability assessments. If the lab, plant, or site receives a patent on an invention, the technology transfer officials then market the patent to find potential licensees or commercialization partners. After they negotiate and the patent owner issues a license, that owner will follow up with the partner to collect royalties, monitor the license performance, and measure outcomes. Researchers may partner with others while researching and developing these inventions.

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- **Strategic Partnership Projects.** A federal lab or facility is paid to conduct research or work on behalf of a sponsor, such as a university, corporation, or other federal agency.
 - **Agreements for the Commercialization of Technology.** These agreements provide national laboratory contractors with flexibility to negotiate with industry partners on terms and conditions with less involvement by DOE than would be required under other agreements.
 - **User-facility agreements.** Under a user-facility agreement, scientists or researchers from outside organizations can use lab equipment for their own research, sometimes in collaboration with lab staff.

The outcomes of technology transfer can include new products or companies based on the transferred technology, improvements to public health or the environment, and scientific publications describing collaborations.

Challenges Associated with Technology Transfer

Prior reporting by GAO and others identified several challenges to technology transfer. We highlight three such challenges.

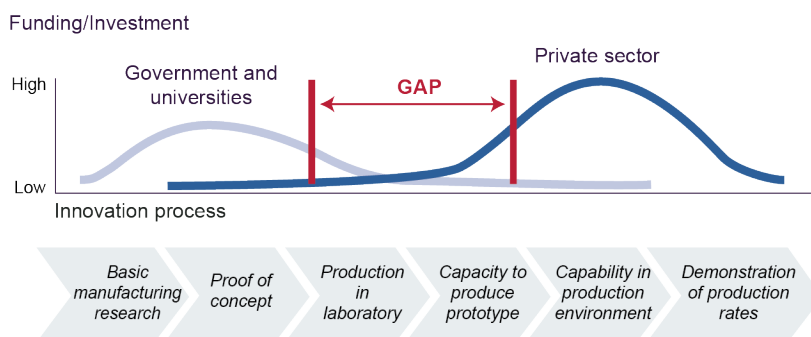
First, several studies have described the “valley of death”—the development phase when federally funded research efforts are ending but before a promising technology has attracted significant private-sector capital to license and commercialize the technology (see fig. 1). In 2009, we found that the valley of death can result in a failure to transfer promising technologies. DOE has limited funding to continue research beyond its initial scope, while potential industry partners are often reluctant to invest in technologies whose potential has not been demonstrated using, for example, performance data or a prototype.¹⁴ In addition, in 2014 we reported that DOE lab technologies are often not developed enough for use in products and may require additional investment.¹⁵ Similarly, in April 2020, a DOE advisory board recommended that the department 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.¹⁶

¹⁴GAO-09-548, p. 23.

¹⁵GAO, *Technology Transfer: Federal Laboratory Consortium Should Increase Communication with Potential Customers to Improve Initiatives*, GAO-15-127 (Washington, D.C.: Oct. 3, 2014).

¹⁶Secretary of Energy Advisory Board, *SEAB Innovation Working Group Initial Findings*, (Washington, D.C.: April 2020).

Figure 1: Illustration of Funding Gap for Commercializing New Technologies



Source: GAO adapted from Executive Office of the President. | GAO-21-202

A second challenge relates to the terms and conditions that govern private-sector partnerships with DOE and the national labs. In 2009, we found the terms and conditions DOE requires in its technology transfer agreements could sometimes complicate negotiations with potential partners.¹⁷ We found that certain terms and conditions may reflect legal requirements and address legitimate policy concerns, but officials at each of the 17 laboratories said that they can also present difficulties for partnering entities, sometimes slowing the negotiating process or discouraging potential partners. In 2014, we reported that the rules and requirements labs must follow in transferring technology increase the complexity and length of time of the negotiations process, creating a disincentive to working with the labs.¹⁸

In 2015, the Commission to Review the Effectiveness of the National Energy Labs found that the barriers to partnership with DOE national labs can be significant for many companies, particularly small businesses. These barriers include the financial cost of collaboration, the complexity of many contract terms, and the length of negotiation and approval

¹⁷[GAO-09-548](#).

¹⁸[GAO-15-127](#).

times.¹⁹ DOE officials and our prior work identified a few specific terms and conditions that can complicate negotiations, including:

- **U.S. manufacturing requirement.** For DOE funding opportunities and partnership agreements, companies must agree to substantially manufacture subject inventions in the United States. Although this presents a challenge for some companies and industries, companies may request waivers from DOE if they can provide compelling information showing that it is not feasible to manufacture a product in the United States or if the product will provide an alternative net benefit to the U.S. economy.²⁰
- **Indemnity.** Collaborative agreements also include language indemnifying, or exempting from legal liability, the government and contractors operating national labs for products, processes, or services made, used, or sold as a result of work conducted under the agreement. According to DOE officials, some partners may not want to assume these legal risks or are prevented from doing so. DOE has taken a risk-based approach to reform its liability requirements under specific circumstances and provide labs with flexibility to negotiate or remove indemnity provisions when appropriate.
- **Government-use rights.** Under the Bayh-Dole Act, the Stevenson-Wydler Act, and other applicable authorities, federal laboratories are authorized to engage in cooperative research and development with non-federal entities and to provide to the collaborator rights in the intellectual property made under such agreements. The government-use rights specified in statute, retain for the government “a nonexclusive, nontransferable, irrevocable, paid-up license to practice or have practiced for or on behalf of the United States any subject invention throughout the world.”²¹ This right may dissuade private

¹⁹Commission to Review the Effectiveness of the National Energy Laboratories, *Securing America's Future: Realizing the Potential of the Department of Energy's National Laboratories* (Oct. 28, 2015).

²⁰DOE may waive domestic manufacturing requirements if contractors or licensees show that reasonable but unsuccessful efforts have been made to substantially manufacture an invention in the United States or that, under existing circumstances, domestic manufacture is not commercially feasible. See 35 U.S.C. § 204 and 2 C.F.R. § 910.366. For additional information see *Federal Research: DOE Is Addressing Invention Disclosure and Other Challenges but Needs a Plan to Guide Data Management Improvements*, [GAO-15-212](#) (Washington, D.C.: Jan. 30, 2015), p. 7.

²¹Bayh-Dole Act, 35 U.S.C. § 202 (c)(4); Stevenson-Wydler Act, 35 U.S.C. § 3710a(b)(1)(A).

companies from investing in a technology, since it might prevent them from selling and licensing the product exclusively.

- **March-in rights.** Under the Bayh-Dole and Stevenson-Wydler Acts, the government retains march-in rights for technologies developed through a collaborative agreement, meaning that if a company does not further develop, license, or commercialize a technology under certain conditions, the government may require the company to grant a license to a third party.²² Companies fear that if they partner with the government or license a federally funded technology, they may ultimately lose intellectual property rights for the invention. However, in a 2009 report, we found that DOE had never exercised this authority; DOE officials confirmed that the department has not done so to date.²³ Further, during our work on a 2018 report, National Institute of Standards and Technology officials told us when potential partners learn that march-in rights have never been exercised, they generally become more comfortable with the march-in right authority.²⁴ Additionally, under certain circumstances, DOE may waive march-in rights in exchange for greater data or other rights, using certain other flexible technology transfer agreements.

A third challenge is identifying and communicating technology transfer opportunities to interested parties. In 2009, we found that a lack of staff with the expertise to identify and promote technologies having commercial promise constrains the number of technologies transferred out of the DOE laboratories or limits laboratories' ability to share their capabilities.²⁵ In 2014, we reported that scientists may not understand the potential commercial applicability of their innovations and that companies are often not aware of the potentially useful technologies being developed

²²The conditions that would allow the federal government to exercise march-in rights are: (1) effective steps have not occurred, or are not expected to occur, within a reasonable time to achieve "practical application" of the subject invention; (2) health and safety needs are not being reasonably satisfied; (3) public use requirements specified by federal regulations must be met; and (4) agreements for U.S. manufacturing have not been met or have been breached. 35 U.S.C. § 203. See also 35 U.S.C. § 3710a(b)(1)(B),(C).

²³We also found this to be the case for the Department of Defense, NASA, and the National Institutes of Health. GAO, *Federal Research: Information on the Government's Right to Assert Ownership Control over Federally Funded Inventions*, [GAO-09-742](#) (Washington, D.C.: July 27, 2009).

²⁴GAO, *Federal Research: Additional Actions Needed to Improve Licensing of Patented Laboratory Inventions*, [GAO-18-327](#) (Washington, D.C.: June 19, 2018), p. 46.

²⁵[GAO-09-548](#).

in the labs.²⁶ And, in October 2020, a DOE advisory board identified areas for improved communication between DOE and industry, including an improved understanding of the state of DOE’s industry engagement and improved awareness of the work done at the national labs.²⁷

DOE Has Addressed Technology Transfer Barriers but Not Training Needs

DOE has several programs to address the following potential barriers to technology transfer: (1) gaps in funding, (2) legal and administrative challenges, and (3) lack of alignment between DOE research and industry needs. However, DOE has not assessed the extent to which national lab, site, and plant researchers have a need for entrepreneurship and commercialization training.

DOE and Laboratory Programs Fund Research with Commercial Potential

DOE and the national labs have several programs to help researchers overcome funding gaps. One significant gap, the aforementioned valley of death, is a period after DOE’s federally funded research effort has ended for a promising technology, but before the technology is mature enough to attract private funding. The department does not have the funding to continue research beyond its initial scope, and private companies are reluctant to assume risks of investing in technologies whose potential has not been demonstrated with a prototype, performance data, or similar evidence.

To address this gap, the Energy Policy Act of 2005 directed DOE to use a portion of its applied energy research budget to establish a Technology Commercialization Fund (TCF).²⁸ TCF, coordinated by OTT, is a funding opportunity that helps researchers further develop energy technologies in collaboration with industry, and identify potential partners. Through TCF, DOE awarded \$33.6 million in funding for 82 projects in fiscal year 2020 and \$24.3 million for 77 projects in fiscal year 2019.

Annually, research teams at the national labs, plants, and sites submit proposals for awards from DOE between \$100,000 and \$1.5 million and

²⁶GAO-15-127. A 2015 study also found that the early stage of development of many DOE technologies was a barrier to partnerships. Department of Energy, *Securing America’s Future: Realizing the Potential of the Department of Energy’s National Laboratories: Final Report of the Commission to Review the Effectiveness of the National Energy Laboratories* (Washington, D.C.: Oct. 28, 2015).

²⁷Secretary of Energy Advisory Board, *SEAB Innovation Working Group Report* (Oct. 13, 2020).

²⁸Energy Policy Act of 2005, Pub. L. No. 109-58, § 1001(e), 119 Stat. 594, 926 (2005) (codified as amended at 42 U.S.C. § 16391(e) (2020)).

lasting from 6 to 36 months. OTT encourages all applicants to partner with a non-federal entity on proposals, and applicants must sign a CRADA or other partnership agreement with an external partner to be eligible for awards of \$250,000 or higher. For awards through 2020, the partner organization provided 50 percent of the total project costs, either from non-federally appropriated funds or as an in-kind contribution, to match the DOE award (i.e., matching funds). OTT provides guidance on annual priorities for the funding opportunity and manages the merit review process. Meanwhile, DOE applied energy program offices select technology areas for proposals and fund awardees.²⁹

Officials from most of the laboratories we spoke with viewed TCF positively and found that their participation helped mature technologies and encouraged private sector communication and partnerships. For example, a research team at the National Renewable Energy Laboratory (NREL) used TCF funding and a partnership with a solar energy company to develop a measurement tool which helps solar power plants and service providers improve efficiency and lower delivered energy costs. According to a researcher involved in the project, the TCF partnership not only provided funding, but also helped the team gain access to solar power plant facilities to test the technology.

However, laboratory representatives noted some challenges to participating in TCF, including the following:

- TCF awards apply to energy-related technologies only, as required by statute.³⁰ Officials from a few laboratories noted that some lab research and technologies related to national and homeland security are therefore not eligible.
- NETL, the only government-owned, government-operated lab, has difficulty participating in TCF due to the matching-funds requirement.³¹ Contractor-operated national laboratories we spoke with use the laboratories' fees and royalties at times to supplement private funding

²⁹TCF participating program offices are EERE, the Office of Nuclear Energy, the Office of Fossil Energy, the Office of Electricity, and the Office of Cybersecurity, Energy Security, and Emergency Response.

³⁰42 U.S.C. § 16391(e) (2020).

³¹42 U.S.C. § 16391(e) (2020). The Consolidated Appropriations Act, 2021, updated the Energy Policy Act of 2005, 42 U.S.C. § 16391(e), to replace the matching-funds requirement with a cost-sharing requirement in accordance with section 988 of the act, 42 U.S.C. § 16352. Pub. L. No. 116-260, div. Z, tit. IX, § 9003, 134 Stat. 1182 (2020).

in TCF projects. However, NETL lacks these resources, so its researchers must rely on the industry partner to fulfil the entirety of the private-sector cost share.

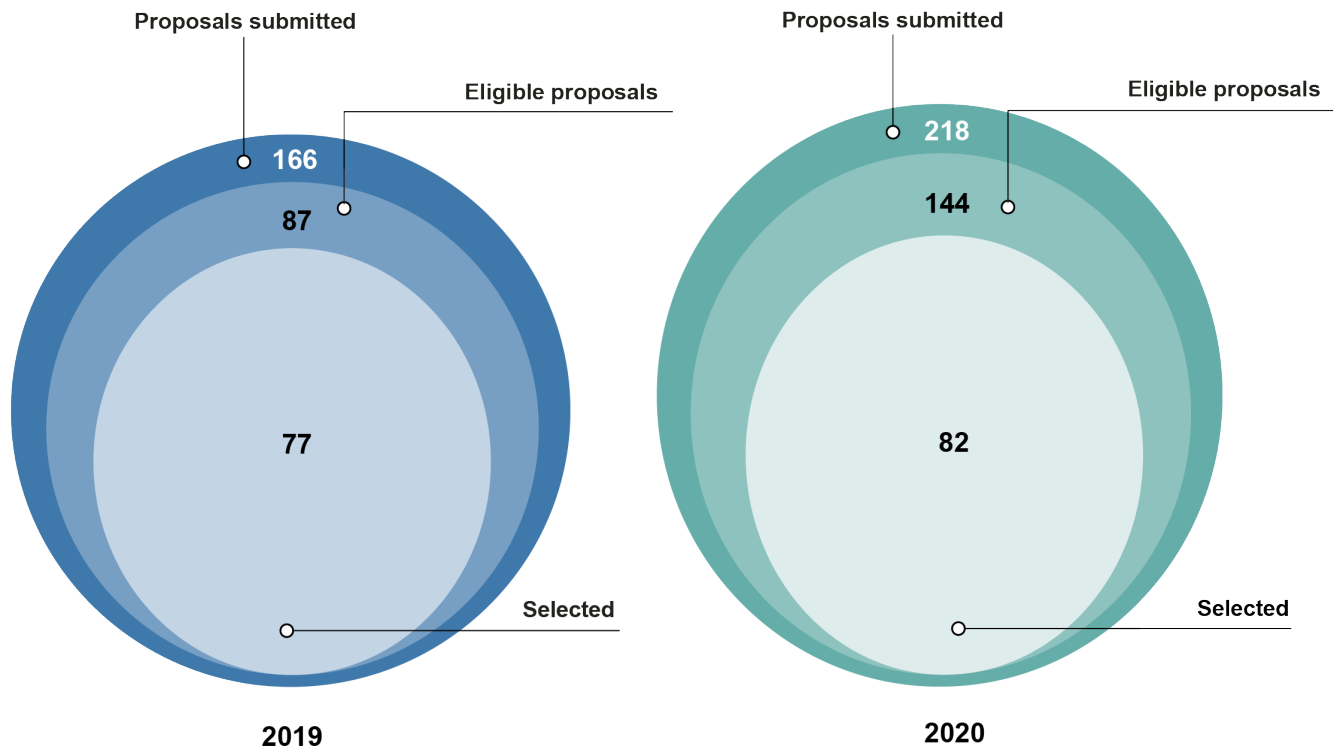
- Officials from most labs and sites noted that it can be difficult to find a private partner to match funds. Some of the laboratories and sites we spoke with said that a lower percentage of required funds would attract more commercial partners. In December 2020, an amendment to the Energy Policy Act changed the matching-funds requirement to a cost-sharing requirement which DOE officials said may help address this challenge.³²
- TCF funding is set by statute and, according to federal officials and laboratory representatives, is not sufficient to fund all meritorious proposals.³³ The department is required to provide 0.9 percent of its applied energy R&D budget for TCF awards. In 2020, OTT reported that 38 percent of TCF proposals were successful (see fig. 2). Proposals that received above a mean score on the merit review met the threshold to be eligible for selection. Twenty-one percent of proposals were denied despite receiving sufficient scores for selection, due to factors such as duplication with other proposals or the need to diversify the number of awardees across DOE facilities.³⁴

³²Consolidated Appropriations Act, 2021, Pub. L. No. 116-120, div. Z, tit. IX, § 9003, Pub. L. No. 116-260, 134 Stat. 1182 (2020).

³³Each TCF proposal undergoes a technical merit review. OTT and program offices consider the merit review and other policy factors, such as funding availability and distribution of awards by topic and national lab, to make final selections.

³⁴The five selection factors considered are: 1) the degree to which the proposed project offers an opportunity to facilitate commercialization of a promising technology that does not currently have other programmatic support, 2) whether the proposed project offers crosscutting or multi-program benefit and passed the mission relevance review, 3) diverse representation of DOE, 4) diversity of technologies, and 5) diversity of projects spanning participating DOE program offices.

Figure 2: Technology Commercialization Fund Awards by the Department of Energy in Fiscal Years 2019 and 2020



Source: GAO analysis of Office of Technology Transitions (OTT) documentation. | GAO-21-202

Note: Eligible proposals are those that received a score above the mean score of all proposals. However, in fiscal year 2020, the threshold score was the mean score for all proposals, while in fiscal year 2019, the threshold score was the mean score for proposals within each program office.

Six of the seven national labs and sites we spoke with use funding sources in addition to TCF—such as licensing royalty income—for dedicated technology maturation programs. For example, Sandia National Laboratories’ Technology Maturation Program uses lab royalty funds to accelerate the commercial adoption of promising technologies. Although awards are typically smaller than TCF awards, the program involves shorter applications and flexible deliverables, according to laboratory representatives. The program also allows the lab to fund the development of national security technologies that would not be eligible for TCF funding. In addition, ARPA-E funds promising energy technologies that require either scale-up or pre-pilot projects to enable a path to market and

commercial impact for its awardees, which may include national labs as participants.³⁵

Lab officials and staff also help researchers find funding sources and partnership opportunities, according to officials at all seven labs and sites we spoke with.³⁶ For example, two NREL researchers noted that lab technology transfer officials assisted with funding opportunities and guided them through the commercialization process, which allowed the researchers to focus on developing the technology. Also, an Idaho National Laboratory (INL) representative stated that the technology transfer office can help match technologies to companies by studying market trends and introducing researchers to potential industry partners.

To help researchers in particular fields, program offices have supported dedicated “test-bed” or prototyping programs, such as the Office of Nuclear Energy’s Gateway for Accelerated Innovations in Nuclear (GAIN) and EERE’s Frontier Observatory for Research in Geothermal Energy (FORGE). Through GAIN, the Office of Nuclear Energy provides vouchers for private companies to use at national labs to cover research and development costs, and it funds private-sector demonstration projects and advanced reactor development. According to DOE officials, GAIN awarded 57 vouchers, ranging between \$50,000 and \$500,000, to outside organizations since its inception in 2016 to help develop high temperature gas, molten salt, and microreactors, among other nuclear energy technologies.

Although federal and lab officials at all seven laboratories and sites said additional investment in these programs could help transition more technologies, it may be difficult to determine what amount of funding is sufficient. The size of the valley of death can change according to various factors—including the field of technology, its maturity, and industry partners’ willingness to pay for further development—and can change over time. Furthermore, the department has not estimated the total

³⁵ARPA-E’s Seeding Critical Advances for Leading Energy technologies with Untapped Potential (SCALE-UP) provides funding for projects to integrate technologies with broader systems, collect additional performance data, or validate the reliability of a new technology so that promising technologies translate into commercial products.

³⁶The officials communicate with researchers about commercially relevant inventions and interact with government and industry stakeholders interested in funding research or developing partnerships to mature and commercialize a technology. Sometimes officials help research teams find relevant funding opportunity announcements, negotiate contracts, and navigate legal requirements.

funding provided for technology transfer across all program offices, labs, sites, and plants.

Also, according to DOE officials, it is difficult for the department to calculate the amount of funding each lab invests in technology transfer activities due to differing organizational structures and business development efforts across labs. However, representatives from one lab stated that no one program can cover the lab's full need for technology maturation funding, so the use of multiple programs allows the lab to guide researchers through the technology transition process and bring technologies to market.

DOE OTT and Working Groups Help Identify and Respond to Legal and Administrative Challenges

DOE also works to identify and address legal and administrative challenges that can inhibit technology transfer. Some legal requirements slow partnership or licensing agreement negotiations, and if management does not facilitate effective administrative review processes and a culture of innovation and entrepreneurship, these requirements may deter researchers from pursuing technology transfer opportunities.

As noted above, in prior work we found that certain required terms and conditions within partnership agreements can make negotiations difficult and discourage potential partnerships.³⁷ Although laboratory officials generally negotiate the agreements with their potential partners, changes to pre-approved agreements must be reviewed by DOE and include certain terms and conditions required by federal law or DOE policy. While these terms and conditions may address legitimate policy concerns, in 2009 we found that officials at each of the 17 laboratories said that they can also present difficulties for partnering entities, sometimes slowing the negotiating process or discouraging potential partners. Similarly, in response to a 2018 request for information on federal technology transfer efforts, AUTM (or the Association of University Technology Managers, Inc., a membership organization that supports technology transfer) suggested that uncertainty related to terms and conditions, such as march-in rights, may limit technology transfer opportunities.³⁸

³⁷[GAO-09-548](#).

³⁸In 2018, NIST issued a Request for Information on federal technology transfer principles and challenges as part of the Presidential Management Agenda's Lab-to-Market cross agency priority goal. National Institute of Standards and Technology, *Return on Investment Initiative for Unleashing American Innovation – Final Green Paper*, Special Publication 1234, (Washington, D.C.: April 2019).

Officials from most labs and program offices we spoke with said that while issues with terms and conditions rarely prevent labs from completing a partnership agreement or licensing transaction, disagreements can delay negotiations. DOE officials also said that some amount of negotiation is necessary because they have a responsibility to ensure that the taxpayer receives a fair return from the department's investments. However, OTT, program office, and lab officials have ways to overcome issues with some terms and conditions. For example, NREL representatives stated that, by using an Agreement for the Commercialization of Technology, the lab was able to successfully negotiate, fund, and de-risk partnerships with two large corporations to create new technology transfer programs, and without the more flexible agreement, the lab could not have formed the partnerships. Similarly, in certain cases, DOE may waive requirements for substantial U.S. manufacturing. Nonetheless, while DOE has tools to negotiate a variety of agreements, three external stakeholders we spoke with were concerned that they would have to share intellectual property rights with the government for intellectual property that originated at the company, prior to the partnership agreement, but was further developed during the partnership with DOE.

To help clarify legal requirements and address administrative challenges in negotiating and approving partnerships and licensing agreements, OTT works with department managers, program officials, and lab representatives through several coordinating groups, including the Technology Transfer Working Group, Technology Transfer Policy Board, and the National Lab Directors' Council. The Technology Transfer Working Group includes OTT, other DOE officials, and national lab representatives who coordinate lab technology transfer activities and exchange information. The Technology Transfer Policy Board allows DOE officials to collaborate on department policy advice. The National Laboratory Technology Transfer working group, within the National Lab Directors' Council, provides an additional forum for lab leaders to discuss technology transition initiatives and challenges.

These coordinating groups allow leaders and technology transfer professionals to share best practices, clarify and streamline technology transition policies and procedures, and propose solutions to common issues across the department. For example, OTT worked with the Technology Transfer Working Group to develop a library of pre-approved terms and conditions for CRADAs and license clauses, covering issues such as laboratory subcontractors, exclusive licenses, and CRADAs with foreign-government-funded research institutions.

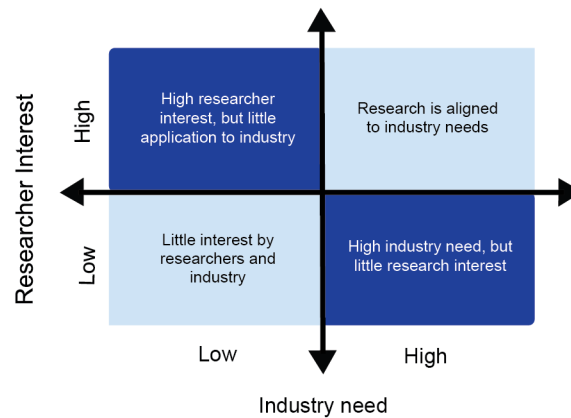
When negotiating agreements, lab technology transfer officials can use different clause examples and options within the library to streamline negotiations, advance through the DOE approval process, and mitigate negotiation delays. Also, based on feedback from the coordinating groups, DOE provided lab contractors with the ability to negotiate and implement master scopes of work to quickly start new CRADAs and Strategic Partnership Projects for routine, ongoing work with outside organizations. According to DOE officials, the department also streamlined approval processes for certain agreements, which reduced the time needed for review.

Administrative priorities, policies, and decisions may also help foster a culture of innovation and entrepreneurship at DOE's facilities. For example, representatives at some labs we spoke with said that even small signs of recognition, like hosting inventor awards ceremonies, can increase lab scientists' participation in technology transfer. Further, lab officials we spoke with noted that researchers are credited with technology transfer efforts within individual performance reviews. Most labs and sites we spoke with said that fostering a culture of innovation and entrepreneurship at the lab improves technology transfer. However, officials representing some laboratories we spoke with suggested that NNSA and DOE leadership could more consistently promote the technology transfer mission by, for example, expanding technology transfer programs and reinforcing support for technology transfer efforts in department or agency communications.

DOE Programs Aim to Align Research with Industry Needs, but DOE Could Better Assess Its Training Needs

DOE has engagement programs to ensure that technology transfer efforts are aligned with industry needs. Officials stated that if researchers align their goals with industry needs, researchers and lab officials increase the chance that a technology will successfully mature, transition to the commercial market, and benefit society. However a technology transfer gap can occur if researchers and industry are focused on different topics, as shown in figure 3. For example, technology transfer officials at Lawrence Berkeley National Laboratory explained that a researcher developed solar cell technology that efficiently converts sunlight to energy, but when the lab officials spoke with industry representatives, they found that industry was more interested in solar panels that could operate for a significantly longer period of time before breaking. Through this experience, the researcher and the lab technology transfer officials learned that it is important to understand industry needs before developing a technology.

Figure 3: Illustration of Potential Mismatch between Researchers and Industry

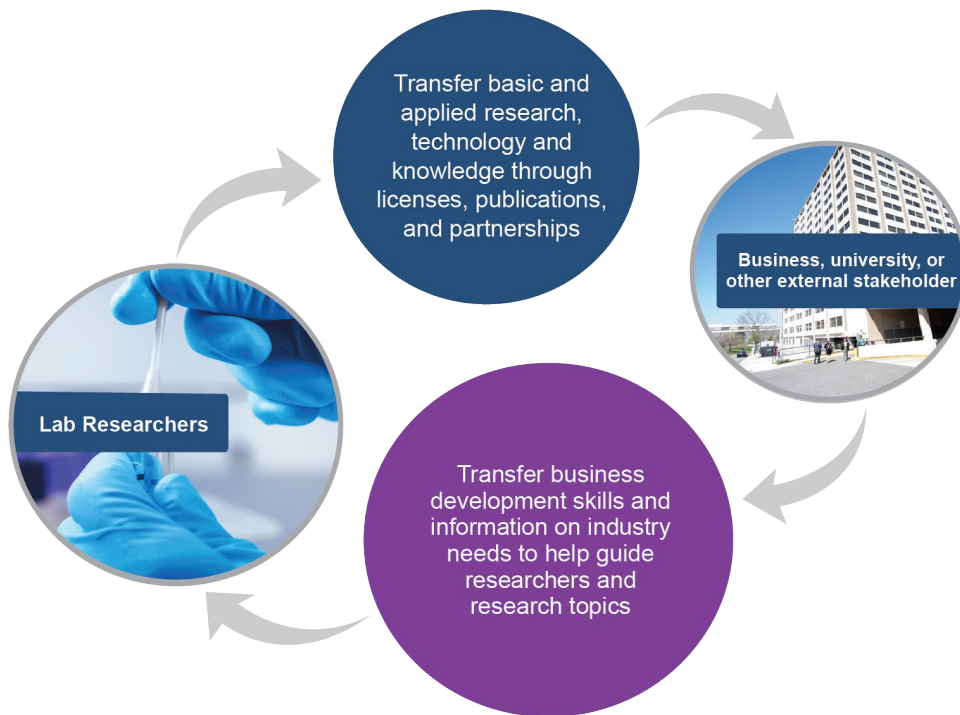


Source: GAO analysis. | GAO-21-202

Engagement between lab researchers and industry, during all phases of development, facilitates successful technology transfer, according to most of the federal officials and laboratory representatives we spoke with. For example, a representative for a large company said that there are significant, fundamental research questions in commercial practice that could be addressed through collaboration. Most officials also noted it may take many years of engagement to develop and commercialize a specific invention, because researchers may not know in advance what companies might make use of a particular technology or whether research projects will succeed.

Researchers can use formal partnerships, like CRADAs, or informal discussions with outside companies to understand industry needs, commercialize and license technologies, and publish useful knowledge in journal articles. Meanwhile, businesses can benefit from the partnerships and communication by gaining a better understanding of lab technologies and capabilities that could advance their industry. Figure 4 illustrates this mutually beneficial relationship.

Figure 4: Illustration of the Benefits of Communication between Researchers and Industry



Source: GAO analysis. | GAO-21-202

By understanding industry needs, researchers can adapt their research to real-world applications, and companies will be more likely to adopt and implement their technologies. One NREL researcher, who partnered with a private company on a TCF project to develop and commercialize a software program that helps engineers design energy-efficient buildings, noted that continuous communication with industry helps researchers demonstrate and validate how a technology can solve a real-world issue for a user. Further, communicating with industry helps researchers understand market issues and time their technology transfer efforts. One official compared these communications and connections to a game of soccer. Soccer teams won't score a goal on every possession, but if the team does not pass the ball then they will never score. Similarly, if labs do not connect and share information with industry throughout a project, then they will not be able to successfully transfer the work.

DOE and the national labs have several programs in place to support greater alignment between researchers and industry, including the following:

- **Matching services.** OTT manages the Lab Partnering Service, a website where it posts information on over 150 experts across different research disciplines, almost 40,000 patents, descriptions of 200 lab user facilities, and partnership success stories.³⁹ The Lab Partnering Service, and similar public- and private-sector matching services, help labs publicize research, equipment, experts, and technologies available for partnerships and licensing.⁴⁰

³⁹OTT collects data on the use of its Lab Partnering Service website, which it created in July 2018. It has not conducted a formal evaluation of its impact due to the limited information it gathers on users after they engage with a lab.

⁴⁰Similarly, the Federal Lab Consortium for Technology Transfer sponsors the Technology Locator Service and FLCBusiness, which post information about research and technologies across federal labs. The information is intended to help potential partners learn about ways to work with lab researchers and license lab technologies.

National Labs and the COVID-19 Pandemic Response

In response to the Coronavirus Disease 2019 (COVID-19) pandemic, the Department of Energy (DOE) implemented the COVID-19 Technical Assistance Program (CTAP) at the national labs. CTAP provides targeted funding to national labs so researchers can offer limited assistance to U.S.-based entities working to resolve technical hurdles in combating the pandemic. The Office of Technology Transitions (OTT) adapted its Lab Partnering Service website to help companies quickly connect with researchers, browse patents available for licensing, and learn about facilities that may be useful in developing countermeasures. To date, 17 projects have begun to support small companies, and state and tribal government entities. Further, Sandia National Laboratories created the COVID-19 Rapid Technology Deployment Program, which allows companies to rapidly license lab intellectual property using a streamlined process and simplified agreement terms. The program's goal is to help businesses economically recover from the crisis, and Sandia officials hope that, by removing potential barriers to technology transfer, it will attract more businesses to partner with the lab and license technologies

Source: GAO analysis. | GAO-21-202

- **Conferences.** DOE connects with the private sector through conferences and industry-specific initiatives. For example, OTT sponsors quarterly conferences called InnovationXLab Summits, where DOE officials and researchers across the national labs discuss ongoing projects and network with potential industry partners in particular fields, such as biomanufacturing or artificial intelligence. Similarly, NREL hosts Industry Growth Forums, where entrepreneurs and investors network with and mentor renewable energy start-up companies. Argonne National Lab works with Fermi National Lab and nearby universities to host the Chicago Quantum Summit, where experts and business representatives discuss the industry's quantum needs and develop an industry roadmap for quantum technology.
- **Industry initiatives.** DOE program offices also coordinate industry-specific research and development road mapping efforts.⁴¹ Further, in January 2020, DOE's Research and Technology Investment Committee, in conjunction with EERE and DOE's Office of Electricity, created the Energy Storage Grand Challenge. Through this effort, the department will coordinate funding and solicit industry feedback to accelerate the development, commercialization, and use of new energy storage technologies.
- **Lab communication efforts.** Aside from DOE organized efforts, lab technology transfer offices also communicate directly with external stakeholders to understand industry needs, and some labs have specific programs or mechanisms to facilitate communication between researchers and private-sector partners. Specifically, Argonne and Sandia assign technology transfer officials to specific research teams so that the officials can better understand the projects and, in turn, help teams consider commercialization opportunities, find partners, manage industry engagements, and communicate the value of the research for end users. Similarly, for ARPA-E projects, the agency's technology-to-market advisors engage with stakeholders, conduct economic analysis, and advise teams on marketing and business development strategies. Most lab technology transfer offices encourage researchers to identify potential partners, develop relationships, and solicit private-sector feedback on their technologies. Some officials noted that when inventors engage directly with partners and develop industry relationships, they can use subject matter expertise to modify the technology to meet partner needs.

⁴¹As mentioned above, industry test-bed programs such as GAIN and FORGE help convene researchers and industry stakeholders to advance the nuclear and geothermal fields, respectively.

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- **Regional outreach initiatives.** Further, some labs use off-campus offices or regional collaboration groups to connect with local businesses and understand their needs. For example, the four national labs with facilities in the San Francisco Bay Area created the Bay Area Lab Innovation Networking Center to coordinate networking and information events for local corporations, start-ups, and investors.⁴²
 - **Entrepreneurship programs.** To help researchers develop entrepreneurship skills, create new start-up companies, and understand industry needs, three national labs we spoke with host lab embedded entrepreneurship programs, which mix business and entrepreneurship training and advice with technical advancement. For example, Lawrence Berkeley lab sponsors Cyclotron Road, which provides 2 years of funding, mentorship, networking opportunities, and training sessions for entrepreneurs to develop new technologies in advanced manufacturing, clean power, and electronics.
 - **Training programs.** Several training programs teach DOE researchers how to communicate with industry and develop entrepreneurship skills and knowledge needed to advance technologies far enough for private sector investment, including Energy I-Corps and Energy I-Corps Satellite Programs. Also, INL trains researchers to use the CO*STAR method, a mnemonic for Customer, Opportunity, Solution, Team, Advantage, Result. According to INL officials, CO*STAR helps researchers discuss the value of a technology, write effective funding proposals, and communicate with potential industry partners and investors. Four hundred of INL's 1,200 researchers have participated in CO*STAR training sessions.

Two training programs from this last category are particularly important, according to DOE and lab officials. Known as Energy I-Corps and Energy I-Corps Satellite Programs, these voluntary programs help researchers identify industry needs and communicate with potential customers. OTT manages Energy I-Corps, which pairs inventors from the labs with industry mentors for a 2-month immersive training course to help the inventors define the value of a technology to a company, conduct interviews with potential customers, and develop commercialization plans

⁴²These labs are Lawrence Berkeley, Lawrence Livermore, and Sandia National Laboratories, along with the SLAC National Accelerator Laboratory (formerly the Stanford Linear Accelerator Center).

to market and implement their technologies.⁴³ For example, scientists at INL we spoke with said that the program taught them to use language that interested business partners, rather than describing overly technical details of the research.

Lab researchers we spoke with who participated in the program noted that it greatly helped them communicate with potential customers, understand industry priorities, and consider how technologies could solve real-world issues. For example, one lab representative said the program can influence the direction of future research and broaden their perspectives to adapt their work to market needs. An independent assessment of Energy I-Corps found that the program increases researcher understanding of the commercialization process and private-sector needs.⁴⁴ According to OTT, 275 lab researchers have participated in Energy I-Corps since 2015, from among more than 20,000 scientists and engineers employed by DOE's national labs. In technical comments on a draft of this report, agency officials raised concerns that extensive training could distract from conducting research. However, we have found that only when the right personnel for the job are on board and are provided the right training, tools, structure, incentives, and responsibilities is operational success possible.⁴⁵

Most laboratories we spoke with said that most researchers would benefit from the training, even those who focus on early-stage research. However, DOE has not assessed the extent to which national lab, site, and plant researchers have a need for such training. Leading principles in workforce planning call for workforce gap assessments, which identify critical occupations, skills, and competencies.⁴⁶ OTT officials told us that they had not conducted such an assessment because the programs are voluntary, and they believe they can scale up or down as needed. Without

⁴³Energy I-Corps Satellite Programs provide limited customer discovery training in a shorter, classroom-based curriculum. Also, DOE and NNSA-sponsored laboratories participate in FedTech, an 8-week, private-sector training program to help teams of entrepreneurs partner with laboratory researchers to develop business plans, build companies, and commercialize the technologies.

⁴⁴Early Stage Impacts of DOE Tech-to-Market Pilots, Evaluation of the Energy I-Corps pilot, NMR Group, Inc. (Feb. 5, 2019).

⁴⁵[GAO-14-704G](#).

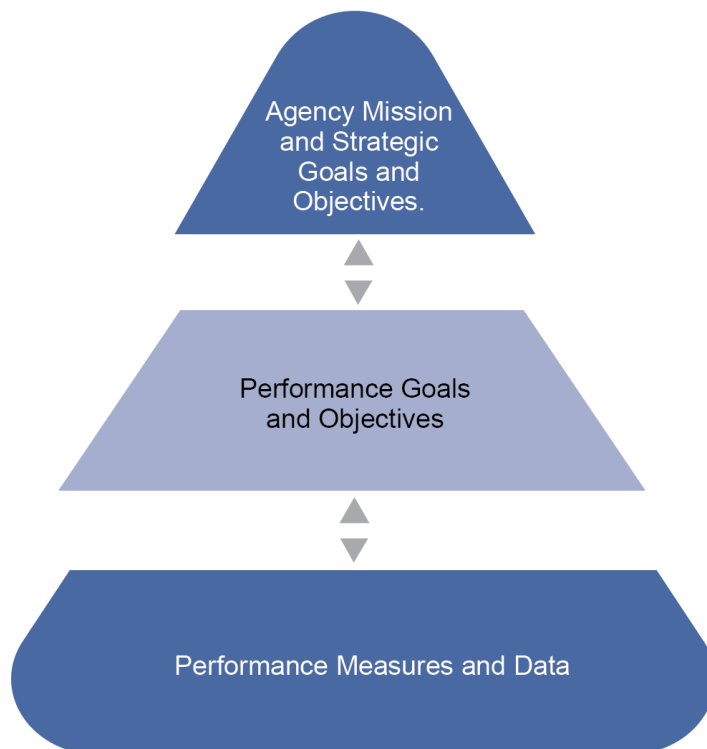
⁴⁶Our previous work and work by the Office of Personnel Management have identified these practices. See *Workforce Planning: Interior, EPA, and the Forest Service Should Strengthen Linkages to Their Strategic Plans and Improve Evaluation*, [GAO-10-413](#) (Washington, D.C.: Mar. 31, 2010).

OTT Lacks Key Tools to Objectively Assess Progress toward Its Technology Transfer Goals

understanding how many and which types of researchers would benefit from training, the department will not have the information needed to ensure limited training resources are targeted to the researchers who would most likely be able to create successful partnerships with industry and transfer technologies to the market.

DOE's technology transfer efforts are extensive, and OTT has developed strategic goals, objectives, and measures for these activities. However, the department does not have objective and measurable performance goals to assess progress toward the broader strategic goals and objectives. Moreover, the existing performance measures are not prioritized and do not align with those strategic goals and objectives, further hindering DOE's ability to assess progress toward them. The relationship among strategic goals and objectives, performance goals, and performance measures and data is depicted in figure 5.

Figure 5: Hierarchy of Performance Information



Source: GAO summary of key attributes described in GAO's prior reporting on performance information and internal control. | GAO-21-202

OTT Has Strategic Goals and Objectives for DOE's Technology Transfer Efforts

OTT has developed strategic goals and objectives for DOE's technology transfer efforts, which are reported in its technology transfer execution plan. This plan is intended to guide and strengthen the department's technology transfer efforts and reinforce the importance of supporting these activities across DOE's facilities and programs, according to OTT. Further, the plan presents a strategic framework of goals, objectives, and key activities to advance DOE's technology transfer mission. OTT issued the most recent execution plan in October 2016, covering fiscal years 2016 through 2018.⁴⁷ The strategic goals are to (1) increase the commercial impact of DOE investments through the transition of national-laboratory-developed technologies into the private sector and (2) increase the commercial impact of DOE investments through private-sector use of national laboratory facilities and expertise. The eight objectives in this plan are listed in table 2. The plan further describes key activities that support each objective, such as pilot programs or assessments of DOE policy. In addition, some individual DOE components have strategic documents that describe their technology transfer efforts.⁴⁸

⁴⁷DOE did not provide us with a draft version of an updated execution plan or an update to the department-wide strategic plan because, according to OTT staff, they were still under review by the department and Office of Management and Budget. In addition, the department has an agency priority goal for 2020-2021 to enable increased commercial adoption and use of DOE technologies and facilities. However, at the time of our review, the department had not published an action plan for this priority goal.

⁴⁸For example, NNSA issued a strategic framework for NNSA-related technology transfer efforts in 2019. NNSA, "Strategic Framework for Technology Transfer 2019-2024" (Sept. 2019). The framework lays out six strategic goals for NNSA's efforts. Further, EERE's 2016-2020 Strategic Plan includes goals related to commercialization and technology transfer. Office of Energy Efficiency and Renewable Energy, "2016-2022 Strategic Plan and Implementing Framework," DOE-EE-1061 (Nov. 2015).

Table 2: Technology Transfer Objectives from the Department of Energy’s (DOE) Fiscal Year 2016-2018 Technology Transfer Execution Plan

Objective 1: Define and elevate the department’s technology transitions mission across DOE’s National Laboratories.

Objective 2: Increase the ease of industry access to national laboratory capabilities and intellectual property.

Objective 3: Enable and encourage national laboratory management and personnel to pursue technology transition activities.

Objective 4: Provide clearer, more accessible, and more comprehensive information on available national laboratory resources to the private sector.

Objective 5: Increase the level and quality of connectivity between DOE’s national laboratories and the private sector.

Objective 6: Enhance the capabilities of national laboratory researchers and technology transfer offices to advance technology transitions.

Objective 7: Support DOE’s national laboratories to provide active collaborative research, strategic partnerships, and facilities access to the private sector.

Objective 8: Support DOE’s national laboratories to mature and subsequently transition federally sponsored technologies for commercial uptake.

Source: GAO presentation of DOE information. | GAO-21-202

OTT Does Not Have Objective and Measurable Performance Goals

OTT’s execution plan describes key activities for each strategic objective, but does not identify specific performance goals to understand agency progress. For example, DOE’s strategic objective to define and elevate the department’s technology transfer mission across the laboratories does not have objective and measurable performance goals associated with it. Ideally, agencies should define performance goals that are generally free of bias, do not require subjective judgments to dominate their measurement, and allow for assessment of progress towards agency objectives.⁴⁹ Instead, the execution plan describes key activities under this objective, such as issuing a Secretarial Policy Statement on technology transfer, setting technology-transfer-related goals for national laboratories as part of DOE’s annual laboratory planning process, and pursuing regular, ongoing engagement between DOE leadership and laboratory leadership and staff.

While these activities may help achieve DOE’s objective, they do not provide measureable performance goals that gauge the department’s progress toward meeting this objective. For example, the key activities listed do not define measures that are potentially subjective, such as “regular, ongoing engagement,” and they lack time frames for completion. Similarly, the execution plan does not identify a performance goal for

⁴⁹[GAO-14-704G](#).

DOE's objective of encouraging researchers to pursue technology transfer activities, such as a target goal for researcher participation. Instead, the execution plan describes key activities, including establishing an awards and recognition program and assessing laboratory conflict-of-interest policies that govern researchers' outside employment.

While the key activities may help DOE accomplish its technology transfer objectives, the extent to which DOE has successfully met the objectives cannot be assessed without objective and measurable performance goals. For example, we found that DOE includes technology transfer in annual laboratory planning documents for all 16 of the contractor-operated national labs, thus completing one of the department's key activities for its objective to define and elevate the technology transfer mission. However, without a performance goal for the objective as a whole, it remains unclear how the completion of this activity affects the department's progress on the objective. Similarly, without a goal for the number of DOE researchers involved in technology transfer activities and a measure of such involvement, DOE cannot assess the extent to which its key activities have met the objective to encourage national laboratory management and personnel to pursue technology transition activities.

Standards for Internal Control in the Federal Government calls for management to define objectives in measurable terms so that performance toward achieving those objectives can be assessed.⁵⁰ According to the standards, measurable objectives may be stated in a quantitative or qualitative form that permits reasonably consistent measurement. The execution plan states that fulfillment of its objectives, and the key activities supporting them, will serve as one measure of the success of this plan. OTT officials told us they did not include measurable performance goals in the execution plan because outcomes from technology transfer efforts are elusive to measure, and output-related goals may not provide an accurate picture of the vigor or impact of these efforts. However, without developing performance goals, OTT cannot effectively assess how projects and key activities contribute to the department's technology transfer mission. Nor can it measure progress toward the strategic goals described in the department's execution plan.

⁵⁰[GAO-14-704G](#)

Existing Measures Do Not Align with Strategic Goals and Objectives

OTT collected over 79 measures of technology transfer from the national labs, plants, and sites in fiscal year 2019, including 28 such measures that were submitted to the Department of Commerce for required annual reporting to Congress.⁵¹ Required measures include the number of patents, licenses to federal intellectual property, active CRADAs, and scientific publications.⁵² In addition, OTT collects data on individual CRADAs and other agreements. OTT coordinates its data collection with the labs, plants, and sites through a standing committee of the Technology Transfer Working Group, which helps OTT define the measures and ensure data are consistent and reliable.

OTT, DOE offices, and the national labs use these measures to understand trends in technology transfer activities at the department. For example, some national lab representatives told us they expect certain measures, like the number of invention disclosures and CRADAs, will be similar from year to year. Therefore, they see year-to-year changes as indicative of either improving or declining performance. However, many national lab representatives also told us that the health of their technology transfer program could not be evaluated on quantitative measures alone. They also use qualitative information, such as judgements of the quality of collaborations. DOE officials told us that all of the metrics are important to collect because the data are used in a variety of contexts to inform different stakeholder groups. The measures also inform DOE's technology transfer utilization report. This report includes information on activities and an explanation of the agency's technology transfer program for the preceding fiscal year, and is a requirement of the Technology Transfer and Commercialization Act of 2000.⁵³

However, the measures are not currently linked to the strategic goals or objectives in the department's technology transfer execution plan, nor are they prioritized. For example, none of the department's current measures

⁵¹OTT collects 79 technology transfer measures from all national laboratories and collects eight additional measures from labs that use Agreements for the Commercialization of Technology.

⁵²Agencies are required to annually report certain measures to the Secretary of Commerce, which in turn submits an annual federal laboratory technology transfer report to the President, U.S. Trade Representative, and Congress. 15 U.S.C. § 3710(f), (g)(2).

⁵³OTT issued the most recent utilization report in October 2019 and it covered fiscal years 2016 and 2017. An OTT official told us the next report should cover fiscal years 2018 and 2019. The Technology Transfer and Commercialization Act of 2000 requires annual agency reports on utilization of federal technology. Pub. L. No. 106-404, § 10(a), 114 Stat. 1742, 1747 (2000) (codified as amended at 15 U.S.C. § 3710(f)).

address the number of laboratory personnel participating in technology transfer activities, a measure vital to assessing DOE's objective to encourage laboratory personnel to pursue technology transfer activities. Further, the department's utilization report does not describe how these measures align with the goals and objectives in the execution plan. Meanwhile, DOE has not identified which measures are most important, so national labs may prioritize different performance goals.

Our prior work has found that choosing performance measures that tell each organizational level how well it is achieving its goals poses an especially difficult challenge for federal managers of research programs, for whom the link between federal efforts and desired outcomes is often difficult to establish and may not be apparent for years.⁵⁴ Nonetheless, producing qualitative or quantitative performance measures for agency goals and objectives allows managers to assess progress and, if necessary, make changes. Managers may use qualitative measures, such as milestones, in circumstances where objectives cannot be defined by quantitative measures. For example, managers may set milestones to complete activities that support a strategic objective by a certain date.

The large number of measures DOE collects may hamper the department's efforts to use the resulting data to assess its performance. Some laboratory representatives told us that collecting and reporting these measures is burdensome due to the time required to compile the information. Our prior work found that the number of measures for each goal at a given organizational level should be limited to the vital few.⁵⁵ Without limiting and prioritizing the number of measures that help DOE to demonstrate results, DOE may risk creating "metric fatigue"—a confusing excess of data that will obscure rather than clarify performance issues.

Conclusions

Technology transfer can help DOE create innovations that solve real-world problems, are economically feasible, and worth the effort and investment. But successful technology transfer requires addressing several barriers, including gaps in funding, management challenges, and the difficulty of aligning research with industry needs. DOE and its national laboratories, sites, and plants have taken numerous actions to address these barriers. For example, DOE invests in training programs, like Energy I-Corps, that teach researchers skills that can help them elucidate industry needs and pursue research that responds accordingly.

⁵⁴[GGD/GAO-96-118](#), p. 26.

⁵⁵[GGD/GAO-96-118](#), p. 27.

But the department has not assessed the extent of training needed for its researchers, which would strengthen its ability to fund and manage its training programs appropriately.

DOE has also established strategic goals and objectives for technology transfer, and it collects many measures for its technology transfer efforts. However, the department does not have measurable performance goals. As a result, current measurement efforts do not allow it to gauge the performance of its technology transfer efforts or to assess progress toward its strategic goals and objectives. Several factors make it difficult to develop objective, quantifiable, and measurable performance goals. Nonetheless, developing quantitative or qualitative performance goals and a limited number of related measures that overcome such difficulties would give the department greater confidence that its technology transfer efforts are effective, inform where adjustments may be needed, and signal its priorities.

Recommendations for Executive Action

We are making the following two recommendations to DOE:

The Director of OTT should assess whether researchers at the national labs, sites, and plants have the skills necessary to effectively identify and collaborate with technology transfer partners, and should provide training to address any skill gaps. (Recommendation 1)

The Director of OTT should develop objective, quantifiable, and measurable performance goals as appropriate, and a limited number of related performance measures or milestones, to assess progress toward the objectives in its technology transfer execution plan and signal priorities. (Recommendation 2)

Agency Comments

We provided a draft of this report to DOE for review and comment. In its comments, reproduced in appendix II, DOE concurred with our recommendations and described steps the department plans to take to address them, including assessing researcher skills and determining flexible, objective performance measures. DOE also provided technical comments, which we incorporated as appropriate.

We are sending copies of this report to the appropriate congressional committees and the Acting Secretary of Energy. In addition, the report is available at no charge on the GAO website at <https://www.gao.gov>.

If you or your staff have any questions about this report, please contact me at (202) 512-6888 or WrightC@gao.gov. Contact points for our

Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix III.

Sincerely yours,

A handwritten signature in black ink that reads "Candice N. Wright". The signature is written in a cursive, flowing style.

Candice N. Wright
Acting Director
Science, Technology Assessment, and Analytics

Appendix I: Scope and Methodology

To examine the steps the Department of Energy (DOE) has taken and the barriers it faces, we reviewed agency and contractor documents related to technology transfer and interviewed federal officials and representatives from government- and contractor-operated laboratories and sites. We spoke with federal officials from a non-generalizable sample of seven DOE components, including the Office of Technology Transitions (OTT), National Nuclear Security Agency (NNSA), and five of 12 program offices. We selected the five program offices with the largest fiscal year 2020 enacted funding. The selected components account for 76 percent of the department’s total funding. In addition, we interviewed representatives from seven selected laboratories or NNSA nuclear production sites sponsored by these components and federal officials who provide local oversight of those labs and sites.¹ For the two components that sponsor multiple labs or sites—DOE’s Office of Science and NNSA—we selected a non-generalizable sample of the two labs or sites with the most technology transfer activities, according to conversations with federal officials and an OTT document that identified technology transfer activities at the department and national labs in 2019. The components, laboratories, and sites we spoke with are listed in table 3.

Table 3: Department of Energy Components, Laboratories, and Sites Included in GAO’s Review

Selected component	Selected laboratories or sites
Office of Technology Transitions (OTT)	n/a
National Nuclear Security Administration	Sandia National Laboratories Kansas City National Security Campus
Office of Science	Argonne National Laboratory Lawrence Berkeley National Laboratory
Office of Energy Efficiency and Renewable Energy	National Renewable Energy Laboratory
Office of Nuclear Energy	Idaho National Laboratory
Office of Fossil Energy	National Energy Technology Laboratory
Advanced Research Projects Agency – Energy (ARPA-E)	n/a

Source: GAO analysis. | GAO-21-202

¹OTT and ARPA-E do not directly oversee any laboratories or sites.

We conducted 50 semi-structured interviews with federal officials, technology transfer professionals, or researchers at the seven DOE components and seven laboratories and sites.² Federal officials include officials from the major program offices responsible for the labs we examined and officials associated federal site or field offices who provide local oversight of those labs. We used these interviews to identify technology transfer and commercialization activities, clarify roles and responsibilities for these activities, and describe common factors to successful and unsuccessful activities, among other things. When describing the results of our interviews, we use the term “most” to describe responses common to representatives from five to seven laboratories or sites; “some” for three to four laboratories or sites; and “a few” for one to two laboratories or sites.

To examine potential barriers, we conducted background research, including a literature search of publications from journals, trade publications, and nonprofit institutions. We conducted searches of various databases, such as ProQuest, Scopus, and Science.gov for publications related to technology transfer at DOE or the federal government within the previous 5 years. We identified 43 articles, studies, or other publications that informed our initial work.

We also interviewed representatives from a non-generalizable sample of 11 external organizations to better understand common barriers they might face when working with DOE and the national labs that could affect DOE’s ability to achieve its technology transfer and commercialization goals and objectives. We selected 10 organizations based on our evaluation of 108 written submissions and four public meeting transcripts from a 2018 request for information by the National Institute of Standards and Technology on federal laboratory technology transfer.³ We reviewed each of the 108 submissions for references to DOE or the national labs and categorized the respondents as belonging to universities,

²A semi-structured interview methodology generally involves asking a similar or standardized set of interview questions of multiple interviewees as a way to collect comparable information. We used a semi-structured interview format with open-ended questions to engage in a conversation about the topics discussed, including common aspects or factors to successful and unsuccessful technology transfer efforts and measures used to gauge commercial impact.

³Department of Commerce, National Institute of Standards and Technology, “Request for Information Regarding Federal Technology Transfer Authorities and Processes.” 83 Fed. Reg. 19,052 (May 1, 2018).

nonprofits/centers, or private companies. We also reviewed transcripts from four public meetings associated with the same request for information to identify additional private companies who spoke about DOE or national laboratories.

Overall, we considered 12 universities, 20 nonprofits/centers, and 23 private companies for interviews. We selected three universities based on those ranked highly for their technology transfer activity, as described in the Milken Institute's 2017 report on the best universities for technology transfer.⁴ We selected three nonprofits based on factors that included the relevance of the nonprofit's comments to our scope. We selected four private-sector companies to include large and small companies with direct involvement in transferring, researching, manufacturing, or partnering on technologies developed at national labs. In addition, we spoke with three individuals, including an academic researcher and two former DOE officials, and two representatives from one additional nonprofit that we identified through other background research.

To examine the extent to which DOE plans and tracks the performance of its current technology transfer and commercialization activities, we reviewed DOE documentation, including the department's most recent strategic plan, technology transfer execution plan, and technology transfer utilization reports. We also evaluated the performance evaluation and measurement plans for all 16 of the department's contractor-operated national labs.

We compared these documents and information from our interviews to our internal control standards and selected key practices for planning and evaluating performance from our prior work. Specifically, we compared DOE's documents to the risk assessment component of internal control—the actions management takes to assess the risks facing the entity as it seeks to achieve its objectives—and the related principle that management should define objectives clearly to enable the identification of risks and define risk tolerances.⁵ We also selected practices from our

⁴Milken Institute Center for Jobs and Human Capital, *Concept to Commercialization: The Best Universities for Technology Transfer* (Santa Monica, Calif.: Milken Institute, 2017), 5. The Milken Institute is a nonprofit, nonpartisan think tank determined to increase global prosperity by advancing collaborative solutions that widen access to capital, create jobs, and improve health.

⁵GAO, *Standards for Internal Control in the Federal Government*, [GAO-14-704G](#) (Washington, D.C.: Sept. 10, 2014).

prior work on planning and evaluating performance related to defining outcomes and measuring performance. Our prior work has found that agencies can encourage greater use of performance information by aligning agency-wide goals and objectives, and by aligning program performance measures at each operating level with those goals and objectives.⁶ In addition, we have found that leading organizations produce a set of performance measures that demonstrate results, are limited to the vital few, respond to multiple priorities, and link to responsible programs.⁷

We conducted this performance audit from October 2019 to January 2021 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

⁶GAO, *Managing For Results: Enhancing Agency Use of Performance Information for Management Decision Making*, [GAO-05-927](#) (Washington, D.C.: Sept. 9, 2005).

⁷GAO, *Executive Guide Effectively Implementing the Government Performance and Results Act*, [GAO/GGD-96-118](#) (Washington, D.C.: June 1996).

Appendix II: Comments from the Department of Energy



The Under Secretary for Science
Washington, DC 20585

January 14, 2021

Ms. Candice N. Wright
Acting Director
Science, Technology Assessment and Analytics
U.S. Government Accountability Office
441 G Street, N.W.
Washington, D.C. 20548

Dear Ms. Wright:

The Department of Energy (DOE) appreciates the opportunity to comment on the Government Accountability Office's (GAO) draft report titled, "*Department of Energy: Improved Performance Planning Could Strengthen Technology Transfer (GAO-21-202)*," dated January 2021 (GAO Code 103846)." DOE concurs with the two recommendations in the report, as discussed in the enclosure.

GAO should direct any questions to Clara Asmail, Senior Advisor for Policy, Office of Technology Transitions, at (240) 781-8090 or clara.asmail@hq.doe.gov.

Sincerely,

A handwritten signature in black ink that reads "Paul M. Dabbar". The signature is written in a cursive, flowing style.

Paul M. Dabbar

Enclosure

Management Response
***GAO Draft Report: Department of Energy:
Improved Performance Planning Could
Strengthen Technology Transfer (GAO-21-202)***

Recommendation #1: *The Director of OTT should assess whether researchers at the national labs, sites and plants have the skills necessary to effectively identify and collaborate with technology transfer partners, and should provide training to address any skill gaps.*

Management Response: Concur

DOE researchers engage in cutting-edge exploratory investigations and development projects that span the spectrum from basic to applied research efforts. Research project teams are of diverse size and composition, which often include researchers focused on different aspects of the overall project. The mission for the national labs, sites, and plants include many research activities unrelated to commercializable outcomes. Due to the diversity of missions and other factors relevant to the skills and competencies of individual researchers, the assessment of whether researchers have the skills necessary to effectively identify and engage with partners will necessarily be localized and time-dependent.

OTT will assess whether researchers at the national labs, sites and plants have the skills necessary to effectively identify and collaborate with technology transfer partners, and develop plans to address any skills gaps.

Estimated Completion Date: December 31, 2022

Recommendation #2: *The Director of OTT should develop objective, quantifiable, and measurable performance goals as appropriate, and a limited number of related performance measures or milestones, to assess progress toward the objectives in its Technology Transfer Execution Plan and signal priorities.*

Management Response: Concur

DOE has refrained from selecting particular technology transfer performance measure(s) to demonstrate technology transfer success. Rather, DOE collects data to understand and illustrate the extent of technology transfer activities.

Upon issuance of the final GAO Audit Report, OTT intends to coordinate with the DOE and NNSA programs that provide oversight to national labs, sites and plants in order to determine flexible, yet objective measures of progress toward DOE technology transfer goals.

Estimated Completion Date: December 31, 2022

Appendix III: GAO Contact and Staff Acknowledgments

GAO Contact

Candice N. Wright (202) 512-6888 or wrightc@gao.gov

Staff Acknowledgments

In addition to the contact name above, Rob Marek (Assistant Director), Tind Shepper Ryen (Analyst-in-charge), Christina Loumeau, and Michael Steinberg made key contributions to this report. Also contributing were Nora Adkins, Cheron Brooks, Pamela Davidson, Ben Licht, Ben Shouse, Jack Wang, and Charla Welch.

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