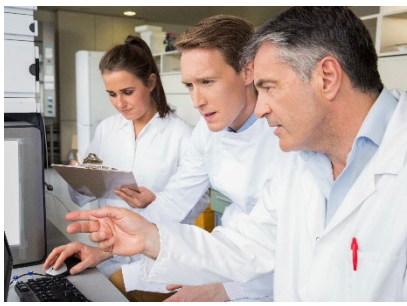
Technology Commercialization Fund: Baseline and Process Report

Final Report

December 31, 2018



research into action inc

Gretchen Jordan, Ph.D.

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Acknowledgements

Research Into Action would like to would like to thank the individuals who contributed to the development of the TCF Baseline and Process Report. Without their support and assistance, this report would not have been possible.

- Don Macdonald, Deputy Director for Strategic Projects at the Department of Energy's Office of Technology Transitions, for his invaluable perspectives on the history of the Technology Commercialization Fund and his guidance on evaluation design and execution.
- Jeff Dowd at the Department of Energy's Energy Efficiency and Renewable Energy Program Office and Yaw Agyeman of Lawrence Berkeley National Laboratory for reading the evaluation plan and providing context on related DOE technology transfer initiatives.
- Melissa Monk, a contractor to the Department of Energy supporting the TCF program, for her continual efforts to keep the evaluation team up to date on TCF activities and supplying the team with necessary information to carry out the evaluation.
- Gretchen Jordan, PhD, for sharing her expertise in technology transfer, providing context around the Department of Energy's National Labs, and providing input on our surveys and an earlier draft of this report.
- The Department of Energy and National Lab staff supporting the TCF program, as well as of lab Principal Investigators and their partners, who graciously participated in our interview research.

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List of Acronyms

AOP	Annual Operating Plan
ARPA-E	Advanced Research Projects Agency-Energy
CRADA	Cooperative Research and Development Agreement
DOE	U.S. Department of Energy
EERE	Office of Energy Efficiency and Renewable Energy
EPAct	Energy Policy Act
FOAs	Funding Opportunity Announcements
FY16	Fiscal Year 2016
FY17	Fiscal Year 2017
FY18	Fiscal Year 2018
INL	Idaho National Laboratory
IP	Intellectual Property
LDRD	Laboratory-Directed Research and Development
LOI	Letter of Intent
NNSA	National Nuclear Security Administration
ORISE	Oak Ridge Institute for Science and Education
OTT	Office of Technology Transitions (DOE)
PI	Principal Investigator
PO	Program Office (DOE)
Q&A	Question and Answer
R&D	Research and Development
SBIR	Small Business Innovation Research
SPP	Strategic Partnership Projects
TCF	Technology Commercialization Fund
TO	Technology Office (DOE)
TRL	Technology Readiness Level
TTO	Technology Transfer Office (national laboratory)

Executive Summary

The Energy Policy Act of 2005 (EPAct) established the Technology Commercialization Fund (TCF) to promote promising energy technologies and their transference from National Labs (labs) to industry. EPAct requires that 0.9% of the U.S. Department of Energy's (DOE's) applied energy research, development, demonstration, and commercial application appropriations for each fiscal year be set aside for the TCF for future planned activities, to be used to provide matching funds with industry partners to promote promising energy technologies for commercial purposes (42 U.S. Code § 16391(e)).

From 2008 to 2016, DOE informally identified projects that met the EPAct TCF requirements. DOE launched the current TCF Program in 2016 with the intention to operate it indefinitely. This report, conducted by an independent evaluator, documents the program's current design (launched in 2016), and presents findings on the following topics:

- Lab approaches to funding technology development and DOE Program Office approaches to funding allocation, prior to (baseline) and after the TCF program launched in its current form,
- TCF-inspired changes in practices and attitudes at the labs and Program Offices (baseline to current study), and
- Process evaluation findings from the perspectives of the DOE Office of Technology Transitions' (OTT) TCF staff, the DOE Program Offices, Lab Technology Transfer Office (TTO) Managers, Principal Investigators (PIs), and industry partners.

The report addresses program activities in Fiscal Years 2016 and 2017 (FY16 and FY17) and provides conclusions and recommendations.

TCF Program Description

Each fiscal year, the DOE OTT issues a solicitation to DOE's 21 research facilities and plants requesting proposals for technologies that have achieved at least early proof of application (Technology Readiness Level (TRL) 3), in one of two topic areas: [1]

- **Topic 1 projects** focus on maturing lab-developed technologies. Awards range from $100,000 to $150,000 with a period of performance of 6 to 12 months.
- **Topic 2 projects** support cooperative development of a lab-developed technology in collaboration with an industry partner for commercial application. Topic 2 awards range from $250,000 to $750,000 and have a period of performance of 12 to 24 months.

Both topics require a 50% cost share of non-federal funds to match DOE's TCF funds. Topic 1 projects may include an industry partner; if they do not have an industry partner, the national lab provides the

[1] TRL characterizes the technology development continuum into nine categories ranging from initial basic research (TRL 1) to technology ready for full commercial deployment (TRL 9).

requisite 50% cost share out of non-federal (usually royalty) funds. For Topic 2 projects, the industry partner normally provides the 50% cost share.

Principal Investigators (PIs), often with support from other lab staff, prepare proposals to respond to the solicitation. Independent merit reviewers, enlisted by DOE for their relevant expertise on the technology and its envisioned application, score the proposals. The DOE Program and Technology Offices review the merit review results and generate a ranked list of proposals they want to fund. A Merit Review Committee holds a one-day meeting to make the selection recommendations. The DOE selection official issues a final approval. After that, the awards are announced, PIs finalize agreements with their industry partners, and DOE Program Offices send funds to the Laboratories for the project work. PIs comply with their Program Office's reporting requirements and submit an end-of-project report.

The research objectives for this baseline report and process evaluation of the FY16 and FY17 TCF program years were: [2]

- To what extent does the TCF program design and program participation stimulate cooperative development with industry and the potential for technology transfer to industry, and attitudinal and behavioral changes at the labs or Program Offices?
- To what extent is the TCF program evidencing adaptive management or continuous improvement, and what are remaining opportunities for improvement?

This report is the first in a series assessing TCF program effectiveness. Subsequent reports will assess technology maturation and develop quantitative estimates of program impacts developed from the deployment of a quasi-experimental design methodology.

Methods

This report presents findings from in-depth interviews conducted with:

- TCF staff from DOE's OTT,
- DOE Program Office and Technology Office managers,
- Lab TTO managers from labs eligible to submit TCF proposals,[3]
- FY17 selected PIs, and
- FY17 selected industry partners.

[2] We refer to the effects we note in this report as "soft impacts;" these soft impacts reflect reported attitudinal and behavioral changes.

[3] See Appendix A for labs eligible to submit TCF proposals.

Key Findings

Baseline and Soft Impacts Findings

Baseline Funding Conditions

There are few funding opportunities and limited funding amounts available to lab researchers other than TCF to advance their technologies toward private sector application through the valley of death, a term commonly used to describe the dearth in funding for mid-stage technology development research**.** TCF fills a key funding gap for lab-developed technology in fledgling stages beyond those typically funded by DOE and prior to those which industry is willing to support. Lab TTO managers reported that neither their labs, nor the Program Offices, would have been likely to fund the TCF-awarded technologies in the absence of the TCF program. (Finding A)

Attitudinal and Behavioral Changes

TCF's structure has increased collaboration between labs and industry partners and increased PI thinking about commercialization. The increased collaboration is most evident for Topic 2 technologies, as the cost share and partnering requirement necessitates lab engagement with industry. PIs responding to the TCF solicitation learned about commercialization, entrepreneurship, and engaging with industry. (Finding B)

TCF has strengthened the role of the lab TTO. Lab TTO staff reported engaging PIs more proactively to respond to the TCF solicitation compared to other funding opportunities. Lab TTO staff also assisted PIs with the commercial impact section of the TCF proposal, which increased intra-lab coordination and made PIs more aware of the support offered by the lab TTO, according to lab contacts. (Finding C)

TCF program design ensures "industry pull" and minimizes "government push." The TCF solicitation and selection process gives the labs more opportunity to do mid-stage energy technology development compared to other DOE funding opportunities and industry has the opportunity, through cost-share, to convey its interest in the technology. With other DOE funding opportunities, the Program Offices outline the types of technologies and applications they want to fund, while the structure of TCF ensures that the Program Offices fund proposals outside those roadmaps deemed meritorious by industry, the labs, and independent reviewers. (Finding D)

Process Evaluation Findings

Solicitation Notification

Predictability of the annual TCF solicitation contributes to the behavioral and attitudinal changes at the labs. The recurrence of the solicitation each year supports ongoing lab-based efforts to cultivate PI awareness of the funding support and foster relationships with potential industry partners, since lab staff know the TCF opportunity will occur again. However, it was not in the same month each year, which made it more challenging to align these lab-based efforts with the solicitation. (Finding E)

PIs and labs appreciated the longer amount of time in FY17 between the solicitation announcement and proposal due date. The longer amount of time afforded more opportunity to engage industry and obtain cost-share commitments. Some PIs added that receiving the solicitation shortly before the winter holidays was a challenge due people's travel plans. (Finding F)

Proposal Preparation

The letter of intent that PIs submitted in advance of a full proposal in FY16 and FY17 caused some unintended negative consequences for the Program Offices and had some unanticipated positive effects for the labs. The Program Offices recruited independent reviewers based on the letters of intent. However, nearly 50% of the PIs who submitted letters of intent did not submit proposals, which meant the Program Offices worked unnecessarily to recruit unneeded reviewers. The labs, on the other hand, found the letter of intent process useful as an advanced notice to align resources within their organizations in support of full proposals. OTT revised the letter of intent process for FY18. (Finding G)

Labs use their royalty funds to fulfill the 50% cost share on Topic 1 proposals, an amount they found required prioritizing. The limited amount of royalty funds in each lab's coffer led many labs to submit proposals for only those technologies they thought had the highest likelihood of selection, rather than submitting all technologies they viewed as worthy of TCF consideration. (Finding H)

Proposal Review Process

Communication and support from OTT to labs and PIs during the solicitation was adequate and well-received. Lab contacts mentioned that the question and answer webinar was very helpful and that TCF staff responded to emails in a timely manner. (Finding I)

Independent merit reviewer recruitment encountered snags in FY16 when OTT charged the Program Offices with this task. The Program Offices identified appropriate reviewers as requested, but OTT found that some identified reviewers were not sufficiently informed nor had committed to the review task. OTT revised the independent merit review process for FY18. (Finding J)

The FY16 and FY17 review processes overall went smoothly, including the independent merit reviews, the Program Office reviews, and the one-day selection meeting. The reviewers had appropriate expertise for the technology proposals they reviewed, and OTT had mechanisms in place to handle the few discrepant reviews, according to contacts. [4] (Finding K)

Notification of Awardees

In FY17, PIs were notified at various times and some award announcements went directly to PIs without informing the lab TTO. The process led to confusion when some PIs learned of their awards sooner than others, and their lab TTOs were unable to provide clarification. PIs were also unsure of whom to contact once awards were issued, not knowing if it was OTT or the funding Office; if the latter, they were unsure of who to contact there. (Finding L)

[4] Three or four independent merit reviewers scored each proposal. Most proposals evidenced reasonable consistency among the scores of the multiple reviewers; a few proposals had discrepant reviews.

The FY17 award announcement delay caused some negative consequences for PIs and industry partners. Interviewed lab contacts mentioned that in some cases industry interest waned or ceased during the time they are waiting for the funding announcement decisions. PIs reported challenges reserving time for their team members and facing other opportunities without knowing whether they would need to dedicate time to the work they budgeted in their TCF proposals. (Finding M)

PIs and lab TTOs found reviewer comments helpful. Some nonselected PIs planned to use reviewer comments to inform applications for future funding. (Finding N)

Execution Process

Most labs and PIs encountered challenges in negotiating Cooperative Research and Development Agreements (CRADAs) with industry partners, though they explained that those challenges were not unique to TCF. The CRADA process was lengthy, often taking more than six months. The solicitation specified a six-month window for CRADA negotiations and some PIs with especially lengthy negotiations said they worried they would lose their awarded funding.[5] (Finding O)

PIs found it a hardship to be involved in lengthy CRADA negotiations, for which they could not bill their time. (Finding P)

The individual funding Program Offices each decide the tracking and reporting requirements for their TCF projects. Many interviewees were unfamiliar with the requirements; those that were familiar expressed support for them. (Finding Q)

Conclusions and Recommendations

Baseline and Soft Impacts

Conclusion 1: The TCF program design stimulated maturation of non-roadmap technology that would not have occurred otherwise. TCF fills a key funding gap between lab-supported research and industry willingness to support lab technologies. Lab TTO managers reported that neither their labs nor the Program Offices, would have been likely to fund the TCF-awarded technologies in the absence of the TCF program. (Findings A, D)

Recommendation: None.

Conclusion 2: The TCF structure leads to new industry partnerships and strengthens existing industry relationships, though the turnaround time coupled with cost share leads many PIs to rely on existing relationships. The TCF Topic 2 opportunity necessitates engagement with industry to fulfil cost share requirements. However, the cost share commitment from an industry partner requires a trusting relationship, which can be challenging to develop from scratch in a few months. This has led some PIs to

[5] No awards in the FY16-FY17 study period were rescinded due to the length of CRADA negotiations. Study does not include 2018 awards.

pursue industry partners with whom they had an existing relationship. All three of our interviewed FY17 industry partners had existing working relationships with the labs. (Findings B, E, F, H)

> **Recommendation: Consider extending the time between the solicitation announcement and proposal submission and publicizing the solicitation schedule one or two years in advance, if OTT seeks to increase the number of awarded projects with industry partners that have never collaborated with a national lab.**

Conclusion 3: TCF implementation has strengthened the interactions of lab TTOs and PIs, and TCF processes can further reinforce the lab TTO. Because the TCF program has a unique focus on technology transfer, the lab TTO is more involved in proposal development than with other funding opportunities. This intra-lab collaboration has heightened PI awareness of lab resources to assist with proposal development and enabled PIs to learn about the commercialization process more broadly. Nonselected PIs have also experienced these effects according to lab TTO contacts. (Findings C, G, H)

> **Recommendation: Maintain the lab TTO as the lab point of contact for TCF program and ensure communication flows through the lab TTO rather than directly to the PIs**.

Process Evaluation

Conclusion 4: OTT has demonstrated continuous improvement by revising its processes. TCF program staff revised the letter of intent process, added explanations of the cash requirement and technology areas to the solicitation, and revised the independent merit reviewer recruitment process. (Findings G, I, J)

> **Recommendation: Continue collecting feedback from lab and Program Office contacts to maintain a commitment to continuous improvement.**

Conclusion 5: Predictability of the TCF solicitation is essential to participants. The annual nature of the solicitation contributes to its effects because it ensures that PI and lab thinking about commercialization and partnering occurs throughout the year. Because building industry relationships takes time and because PIs and the labs know TCF will be available again, they described cultivating industry relationships throughout the year and looking at how to position technologies under development to attract industry partners. However, inconsistent issuance of the annual solicitation weakened the ability of the labs to effectively prepare for these planning efforts. (Findings E, F, G)

> **Recommendation: Maintain consistency in the timing of the TCF solicitation year-to-year to support these ongoing, lab-based planning efforts.**

Conclusion 6: Potentially viable technologies appear to exceed submitted proposals as labs need to limit their exposure to the lab cost share requirements; and industry cost share requirement is a barrier to partnerships with small businesses. Most labs reported restricting the number of Topic 1 proposals they submit to TCF as their limited lab royalty funds would not be able to support all technologies they believed worthy of TCF consideration. Lab contacts reported challenges in engaging smaller partners. (Finding H)

> **Recommendation: Consider feasibility of a reduced cost share on Topic 1 proposals, especially select technology areas for which OTT might want to receive a greater number of proposals.**

Recommendation: Consider approaches to facilitate small business and start-up participation, such as coupling TCF and SBV awards.

Conclusion 7: Improvement is needed in the award notification process and in communication from Program Offices to selected labs and PIs. The award notification process used in FY16 and FY17 caused confusion for lab PIs and TTO managers. PIs at the same lab were notified at different times and only sometimes was the lab TTO informed of award decisions. PIs and labs report uncertainty about who to contact and who to report to after award announcement. PIs also desired better communication about reporting requirements, which are set by the funding Office. (Findings L, M)

Recommendation: Standardize selection notification process so that announcements for all PIs occur at the same time and go first or concurrently to the lab's TTO managers.

Recommendation: Establish protocols for how the Program and Technology Offices initially communicate with the selected PIs. Provide a point of contact for PIs and industry partners to contact about TCF once responsibility passes from OTT.

Conclusion 8: CRADA negotiations between industry partners and labs can be protracted, negatively affecting PIs and partners. Industry interest can wane in the time elapsed between proposal submission and project start dates. PIs do not have a way to bill for their work during contract negotiations. (Findings O, P)

Recommendation: Consider authorizing PIs to charge a small amount of the TCF contract award for their time spent involved in CRADA negotiations (for example, up to 2%).

Recommendation: Add an appendix to the TCF solicitation that includes a representative CRADA (absent a statement of work) so that industry partners are aware of typical CRADA terms prior to committing to partner on the proposal.

Recommendation: Consider advocating within DOE for continued study of CRADA negotiation challenges with the goal of identifying ways to improve the process.

1. Introduction

This document presents a baseline and process evaluation of the Department of Energy (DOE) Office of Technology Transitions' (OTT's) Technology Commercialization Fund (TCF). The document first describes the baseline for lab approaches to technology transfer and DOE Program Office approaches to funding allocation prior to the launch of the TCF program in its current form. In tandem with that, it addresses TCF's "soft impacts," that is, changes to those approaches and attitudes from program launch through our data collection in early 2018. Secondly, the document provides a process evaluation of TCF program processes in Fiscal Years 2016 (FY16) and 2017 (FY17).

1.1. Background

DOE is charged with "ensur[ing] America's security and prosperity by addressing its energy, environmental, and nuclear challenges through transformative science and technology solutions." It conducts this science and technology development by directing and funding research at 21 national laboratories (labs) and additional research facilities, organizations created and supported by the Federal government to perform research and development (R&D) in areas of importance to DOE and, as appropriate, other Federal agencies.[6] TCF is one of several DOE technology maturation programs, each with a unique purpose and design; it is one of two programs that targets lab researchers and the only one that provides those researchers with funding.[7]

The TCF is a roughly $20 million annual funding opportunity that leverages the R&D funding in DOE's applied energy programs to mature promising energy technologies with the potential for high impact. Since 1940, DOE research and technology development has resulted in more than 37,000 individual U.S. patents across a wide range of technologies, many of which have been the foundation of technologies that made it into commercial markets.[8,9]

The technology development and commercialization journey is frequently described as a linear process that begins with ideation and basic research, progressing through applied research, proof-of-concept, and proof of application, to the development and validation of a series of increasingly larger and more expensive prototypes (working, engineering, and production). If this progression goes well and industry sees a market and good potential return on investment, the technology is scaled up and if it is validated in the commercial environment, launched into the commercial marketplace. This idealized linear model is generally understood among researchers to describe a non-linear, iterative process that is contingent on many factors. Even so, the steps of the simple linear model are useful in assessing technology development over time and across technologies. DOE and other federal agencies adopted a framework

6 Appendix A provides a list of the twenty national laboratories and additional research facilities.

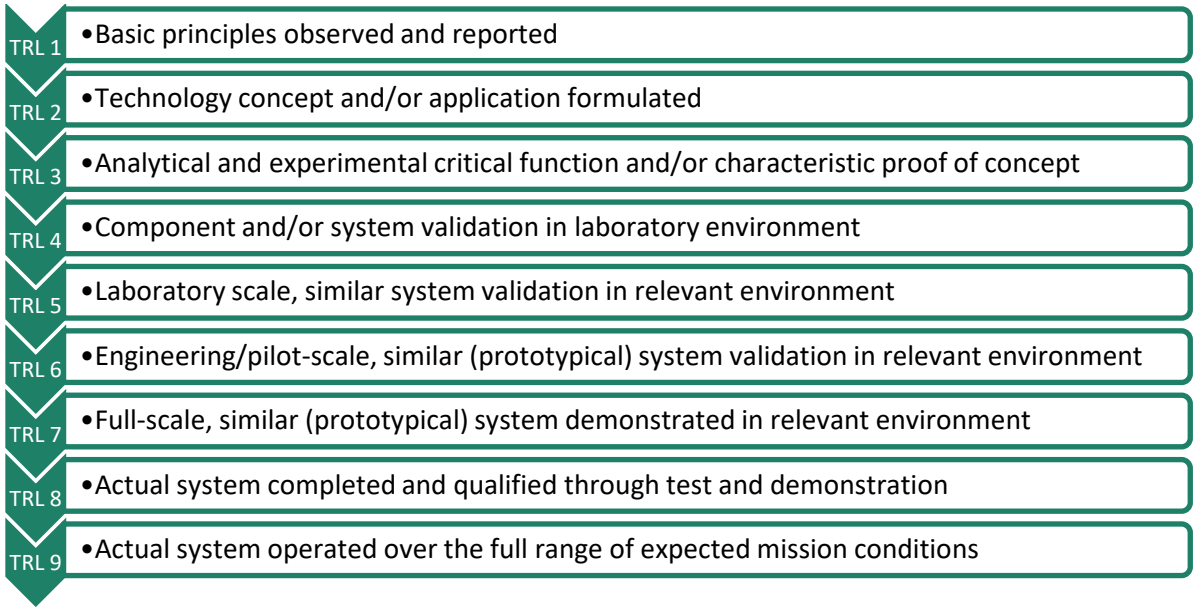
7 Table 2-2 summarizes these DOE technology maturation programs and Appendix B briefly describes them. Energy I-Corps is the other DOE program that targets lab researchers; it provides researchers with commercialization training.

8 Prior to the Department of Energy Organization Act of 1977, which created the DOE, some of the patents were associated with preceding organizations such as the U.S. Atomic Energy Commission, Energy Research and Development Administration, and the Nuclear Regulatory Commission.

9 *https://www.osti.gov/doepatents/search/sort:publication_date%20asc*

of Technology Readiness Levels (TRLs) to communicate where on the linear commercialization model a technology is relative to a specific application (Figure 1-1). TRL is a communication tool, not a decision-making process.

Figure 1-1: Technology Readiness Levels



Department of Energy (DOE). 2011. *Technology Readiness Assessment Guide.* DOE G 413.3-4.

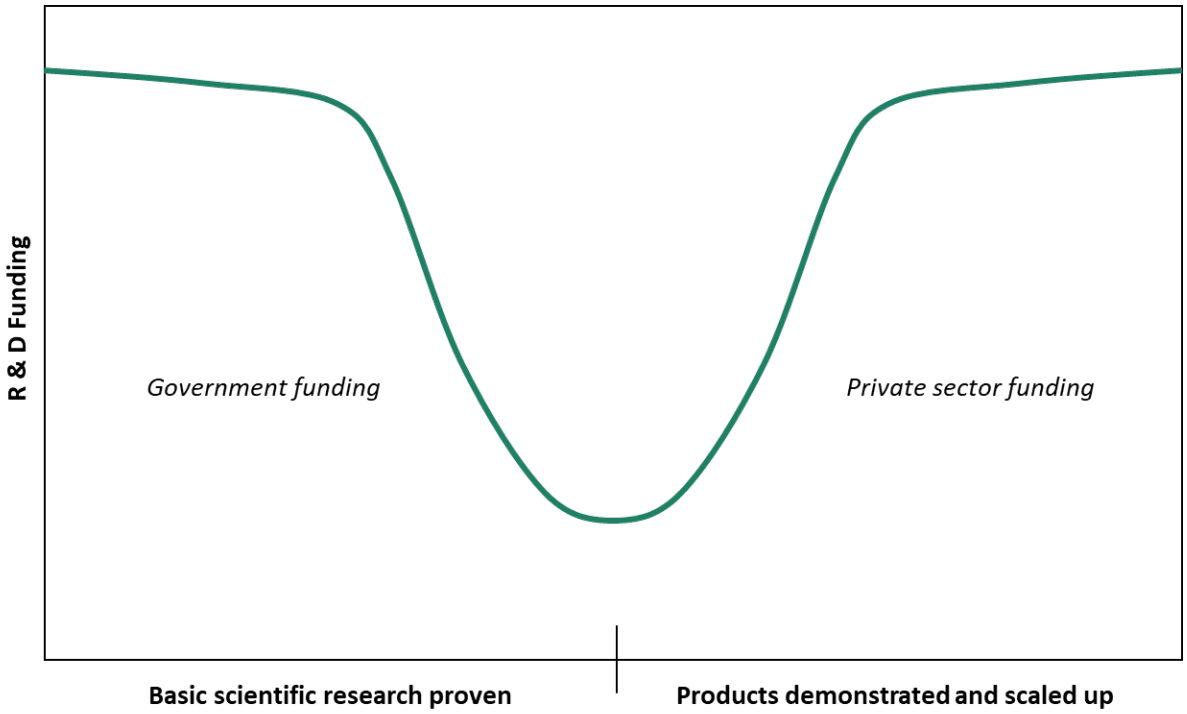
The role of the U.S. federal government is to serve the public good, which includes to step in where there is a systemic failure of the market to act. This role argues for the government to fund basic and early applied research (typically TRLs less than 4) and to leave the market to fund those potential technologies it sees reason to fund. Many energy sector technologies incur market failures because energy shares features with public goods, including national security, environmental and health protection, and protection of U.S. firms from unfair international competition. These characteristics mean the benefits are larger than what the private sector would garner and thus would be willing to fund. Also, the high capital costs associated with many new energy technologies increases the risk for industry. For these and other reasons the U.S. Congress has authorized federal funding for "technology maturation," TRLs 4-5, with cost-share funding from industry to ensure there is market interest (market pull) for the technology that receives funding.

The process of disseminating pre-commercial technologies from their place of origin in the public research sector to partners in industry is referred to as *technology transfer*. Industry prepares the technology for commercialization and launches it into the market after transfer from the research sector. Starting in the 1980s, Congress began passing laws acknowledging the critical role that U.S. federal agencies, such as DOE, can play in technology transfer – particularly helping to fund the development of technologies at stages when uncertainty and thus financial risk preclude sufficient private investment for further development.

Significant financial investment – and risk tolerance – typically is needed to advance technologies beyond the initial basic and applied research stages, because proof-of-application and prototyping are

increasingly costly as development moves forward. Hence, funding for early development by industry is often sparse, yet significant work remains to develop the technology sufficiently to attract private investors. This funding gap prevents a substantial number of promising technologies or intellectual properties from making it into the market. This gap is often referred to as the "v*alley of death*" (Figure 1-2).

Figure 1-2: The "Valley of Death" between Public and Private Sector Development Activities



Some have further delineated this issue by distinguishing between a "technological valley of death" and a "commercialization valley of death."[10] According to these researchers, the *technological valley of death* exists after the basic and applied research stages (TRLs 1-3) and represents the specific lack of funding that exists in bringing technologies or intellectual property (IP) through proof-of-application (TRL 4). The *commercialization valley of death*, in contrast, exists later in a technology's development, when innovators need funds to verify that a technology can be brought into full-scale production and manufacturing (likely TRLs 5-8).

DOE, founded in 1977, conducted maturation support activities to address this gap. To address its own critiques of DOE's early maturation support activities, as well as other considerations, Congress passed the Energy Policy Act (EPAct) of 2005 (P. L. 109-58). Section 1001(e) of EPAct emphasizes DOE's role in technology maturation by earmarking funds for commercialization activities targeted to earlier-stage R&D DOE conducts through the labs.[11] A matching funds clause in the legislation helps ensure that

[10] Jenkins, J. and S. Mansur. 2011. *Bridging the Clean Energy Valleys of Death: Helping American Entrepreneurs Meet the Nation's Energy Innovation Imperative*. The Breakthrough Institute. Oakland, CA. *https://thebreakthrough.org/blog/Valleys_of_Death.pdf*

[11] The commercialization funds are a percentage (0.9%) of selected DOE R&D budgets and do not augment those budgets.

industry is empowered to decide which technologies advance (that is, the legislation promotes market pull rather than government push) by selecting which projects to collaborate on and to co-fund.

DOE's initial implementation of the fund lasted two years, ending in 2008, and was criticized for how project selections were made by headquarters personnel funding DOE's existing research agenda (potentially resulting in a certain degree of government push), rather than considering the relative merits of lab-developed innovations.[12] From 2008 to 2016, DOE informally identified projects that met the EPAct TCF requirements.

DOE launched the current TCF Program in 2016 with the intention to operate it indefinitely. The TCF Program differs from these earlier efforts in that it provides a DOE-wide effort that: (1) focuses on bridging the initial stages of the valley of death – or more specifically, the technological valley of death, and (2) provides a consistent and coordinated competitive selection process for R&D efforts that have the greatest commercialization promise. The government push that was possible with some earlier technology maturation efforts is reduced in TCF by the selection requirements, the merit review, and proposal selection processes, as well as the "industry-pull" requirement for industry matching funds (either in-kind, monetary, or both).[13]

The TCF Program relies on 0.9 percent of the funding from the DOE's applied energy research, development, demonstration, and commercial application budget for each fiscal year from four DOE Program Offices: the Office of Fossil Energy, Office of Nuclear Energy, Office of Electricity, and Office of Energy Efficiency and Renewable Energy, which in turn comprises nine Technology Offices. Projects can fall into one of two possible topic areas:

- **Topic 1**: **Technology Maturation Projects -** These projects focus on maturing lab-developed technologies with commercial potential to attract a private partner or internal laboratory funds (license royalties and other non-federal sources, not DOE contract funds) and which have reached at least a TRL 3.
  - Target TCF funding per award: $100,000-$150,000.
  - The target period of performance: 6-12 months.
- **Topic 2: Cooperative Development Projects -** These projects support cooperative development of a lab-developed technology in collaboration with a private partner for commercial application. This topic focuses on technologies where the laboratory has already identified a commercial partner willing to execute a technology partnership agreement (for example, Cooperative Research and Development Agreement [CRADA]). Technologies will have already undergone some form of evaluation by the lab to determine if they are viable for commercialization.
  - Target TCF funding per award: $250,000-$750,000.
  - Target period of performance: 12-24 months.

[12] Jenkins and Mansur, Loc. Cit., p.8

[13] This cost share requirement is applied to other Program Office projects, not just TCF.

1.2. Research Objectives

The research objective for the baseline and soft impacts investigation (Chapter 2) was:

- To what extent does TCF program design and program participation stimulate cooperative development with and the potential for technology transfer to industry, and attitudinal and behavioral changes at the labs or Program Offices.

The FY16 and FY17 process evaluation's (Chapter 3) research objective was:

- To what extent is the TCF program evidencing adaptive management or continuous improvement, and what are remaining opportunities for improvement?

1.3. Methodology

Our investigation included collecting data from several sources to capture a well-rounded perspective of the TCF program (Table 1-1). We conducted baseline interviews with TCF program representatives at DOE (within OTT and DOE Program Offices (POs) and Technology Offices (TOs)) and at 15 of the 17 labs eligible to participate in TCF in 2016.[14] Lab contacts we spoke with were managers situated at the lab's Technology Transfer Offices or Sponsored Partnerships Offices (we refer to these respondents as lab TTO managers). The purpose of the baseline conversations was to capture business-as-usual practices prior to the TCF program in its current form and to learn whether involvement in TCF had inspired changes elsewhere in their work. We conducted process evaluation interviews with representatives in OTT, DOE Program Offices, and 11 of the 12 labs with awarded projects in FY16 and FY17, as well as Principal Investigators (PIs) and industry partners.[15] Appendix D includes the interview guides.

Table 1-1: Data Collection Efforts

Group	Population	Number of Interviews	Interviews Fielded
Baseline Interviews			
DOE OTT TCF Managers; Program and Technology Office Managers	2 OTT managers 5 PO managers 9 TO managers	2 OTT managers 4 PO managers 2 TO managers	April 2018
Lab TTO Managers	12 participating labs 5 nonparticipating labs	11 participating labs 4 nonparticipating labs	February and March 2018

Continued…

[14] In 2017, DOE expanded eligibility to DOE plants and production facilities.

[15] We interviewed some individuals for both the baseline and process investigations. Some individuals participated in one of these investigations. In total, we obtained the perspectives of more than 30 contacts.

Group	Population	Number of Interviews	Interviews Fielded
Process Interviews			
DOE OTT TCF Managers; Program Office Managers	2 OTT managers 5 PO managers 1 INL coordinator*	1 OTT manager 4 PO managers 1 INL coordinator	August and September 2017
Lab TTO Managers	12 participating labs	11 participating labs	November and December 2017
FY17 Selected Principal Investigators (PIs)	25 Topic 1 PIs 23 Topic 2 PIs	5 Topic 1 PIs 4 Topic 2 PIs	April 2018
FY17 Private Sector Partners	54 partners	3 partners	April and May 2018

* INL is Idaho National Lab, which runs the TCF solicitation portal.

Appendix C provides a discussion of the TCF program logic.

Report Organization

Chapter 2: Baseline and Soft Impacts presents findings about lab approaches to funding technology maturation and DOE Program Office approaches to funding allocation prior to and after the TCF program launched in its current form (pre-2016 through 2017), highlighting the changes that occurred with TCF. Chapter 3: Process Evaluation presents findings from the perspectives of the DOE Program Offices, Lab TTO Managers, Principal Investigators, and industry partners. Chapter 4 presents conclusions and recommendations.

2. Baseline and Soft Impacts

This chapter presents a characterization of baseline conditions prior to the launch in 2016 of the TCF program in its current form, including compliance with the EPAct, funding available to PIs to support research through the valley of death, and how TCF differs from those funding opportunities. Next, we describe how the TCF program has encouraged changes in approaches and attitudes at the lab, as reported by lab TTO managers, and the relatively fewer changes that have occurred at the Program Offices.

2.1. Compliance with Energy Policy Act

Prior to the current TCF program, the DOE Program Offices demonstrated compliance with EPAct's requirement "to support projects with matching private funds to promote promising energy technologies for commercial purposes," by counting the prior fiscal year's CRADA projects with an industry partner. While our respondents were not personally involved in receiving feedback on this documentation, they reported that the Department received criticism from Congress or the DOE Inspector General's Office that it was not complying with the law but was instead continuing business as usual and retroactively accounting for the funding. It was out of this criticism that Congress amended EPAct's language earlier this decade to specify that TCF funds must be allocated to future, planned activities and is partly how the TCF program in this evaluation came to be.

2.2. Few Other Funding Opportunities Available to Lab Researchers to Cross Valley of Death

There are few funding opportunities and limited funding amounts available to lab researchers in addition to TCF to advance technologies they are interested in through the valley of death, according to lab TTO managers. DOE Program Offices have their own strategic priorities and typically fund only research leading up to the valley of death. The DOE laboratories can direct a small percentage of their operating budgets toward research of their choosing (lab-directed research and development [LDRD] funds), but these funds target very early stage research, typically prior to programmatic funding selected by the lab director.[16]

Contacts at eight labs reported they use their own royalty funds to advance technologies through the valley of death to the point where they can attract private industry funding . These labs allocate the funds through their own competitive technology investment or maturation programs, but the amounts they can provide PIs are smaller than what TCF supplies. The award sizes range from $35,000 to $200,000 and most labs award fewer than five projects a year; the most "generous" lab reportedly funds

[16] LDRD, established by federal legislation, provides labs with the financial and administrative ability to explore new research concepts not yet well-enough developed to be adopted by government programs. DOE attributes LDRD with having contributed to and often having been the initial motivation for major DOE Science and Technology advances. Sixteen labs currently have LDRD programs. By statute, a laboratory's maximum allowable LDRD funding is 6% of its annual operating/equipment budget. LDRED is accumulated as part of the overhead rate charged by a lab to each of its DOE and non-DOE funders on lab work. It is considered a normal cost of doing business. https://science.energy.gov/lp/laboratory-directed-research-and-development/frequently-asked-questions/

up to ten projects per year. The labs' royalty streams are limited and, in some cases, dwindling. Lab managers said these smaller investments can help further the technologies but are often not enough to support the technology through commercialization.

The contacts at the remaining nine labs did not mention royalty funds in response to the question "What funding sources are available to researchers to advance their technologies along the commercialization continuum, through the so-called valley of death, commonly considered to be TRL 4 and 5?"[17] To develop a point of comparison with TCF, let us assume that ten labs use their own royalty funds in this way.[18] Continuing the assumptions for point of comparison, let us assume that the ten labs each use royalty funds for five projects annually with an average project funded at $75,000. Under these assumptions, which we believe to be conservative (that is, likely erring on the high side) the labs collectively are providing $3,750,000 annually to help projects advance along the commercialization continuum. This compares with roughly $20,000,000 annual TCF funding. Further, PIs can only access these monies if they work for one of the labs using royalty funds in this way.

Seven labs reported exploring funding from state grants, including from the California Energy Commission, or universities to support research through the valley of death, to limited success. Two labs reported entering pitch competitions, and one lab's PI won $5,000 at one competition for technology maturation.

Table 2-1 summarizes the sources of funding PIs pursued during the baseline period to support research and development on their technologies, and their weaknesses compared to TCF.

Table 2-1: Other Funding Opportunities Reported by Lab Managers

Source	Details	Weaknesses compared to TCF
DOE	Program Office funding opportunities	Supports research leading up to, but not crossing, valley of death
	Small Business Vouchers [a]	Supports small business-directed research; funding provided by EERE
	Small Business Innovation Research (SBIR) & Small Business Technology Transfer (STTR) [a]	Supports small business-directed research
National Lab	LDRD Funds	Very early stage research, typically prior Program Office funding
	Royalty Streams	Small amounts available from some labs
Private Partner Funding	CRADAs	Supports private partner-directed research
	Strategic Partnership Projects (SPP) [b]	

Continued…

17 Interviewers probed, per instructions, to ensure contact considered all types of entities – DOE, lab, partners, and any other source.

18 The lack of a response to an open-ended question is different from a negative response to a closed-ended question. To be conservative in the point of comparison with TCF, we assume an additional three labs use royalty funds to support commercialization advancement beyond the seven labs that reported doing so.

Source	Details	Weaknesses compared to TCF
State	California Energy Commission	Contractual issues complicated; rare to use
	State of Colorado, Office of Economic Trade, Proof of Concept grant	Limited participation reported among researchers
Universities	Grants or pitch competitions	Small awards available; researchers have applied but not won [c]

[a] See Appendix B.

[b] SPP enables labs to conduct work using DOE facilities for non-DOE entities, such as industry, small businesses, or other federal agencies. SPP is a contractual mechanism and not a programmatic initiative; programmatic initiatives are identified in Appendix B.

[c] One researcher won one prize in baseline period.

TCF is one of seven currently active DOE initiatives relating to technology commercialization; two other commercialization-related initiatives ended in 2017, after TCF launched. Table 2-2 provides a brief characterization of these initiatives to suggest the extent to which they serve lab researchers seeking to commercialize their innovations. (Appendix B further describes these initiatives.) Only two of the nine initiatives target DOE lab researchers – TCF and Energy I-Corps, which provides lab researchers with training relevant to commercialization. Of the remainder, two serve or served small businesses, three serve or served non-federal researchers and two serve private investors. Only TCF provides funding opportunities to lab researchers interested in furthering their innovations along the commercialization continuum.

Table 2-2: Characterization of DOE Technology Commercialization Initiatives and Relevance to Assessment of TCF Impacts

Initiative	Duration	Primary Audience Served	Services / Benefit Provided
Technology Commercialization Fund (TCF)	**2016 to present**	**DOE Lab researchers**	**Funding**
Lab Partnering Service (LPS)	2018 to present	Innovators (researchers) investors, and institutions	Information, facilitation
Energy Investor Center (EIC)	2016 to present	Private investors	Information, facilitation
Energy I-Corps	2015 to present	DOE Lab researchers	Training
Lab-Embedded Entrepreneurship Programs (LEEP)*	2014 to present	Non-federal researchers	Access to lab resources; limited to technologies of interest to EERE's Advanced Manufacturing Office
Energy Innovation Portal	2010 to present	Private investors	Information, facilitation

Continued…

Initiative	Duration	Primary Audience Served	Services / Benefit Provided
Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR)	1983 to present	U.S. small businesses	Funding, option to access lab resources
Small Business Voucher (SBV)	2015 to 2017	U.S. small businesses	Funding to access lab resources
Agreement for Commercializing Technology (ACT)	2011 to 2017	Non-federal researchers	Access to lab resources

* Currently comprises three programs: Cyclotron Road at Lawrence Berkeley National Laboratory, Chain Reaction Innovations at Argonne National Laboratory, and Innovation Crossroads at Oak Ridge National Laboratory.

TCF has ameliorated a key gap between public and private funding, addressing the valley of death. Almost all interviewed FY16 participating labs (10 of 11 labs) made unsolicited comments about how valuable TCF is and how they rely on TCF to fill that gap and support technologies across the valley of death.[19] Half of the interviewed nonparticipating labs (2 of 4) also mentioned unprompted that TCF fills a critical gap in funding that researchers need.[20] One participating lab contact described why the TCF opportunity is critical to their lab's researchers:

> *"Rather than hitting the wall and leaving that technology on the shelf and turning their attention to the next problem, they now have this opportunity to take the technology further than they typically would have been able to with traditional sources of funding. It opens up that TRL space that they wouldn't normally be able to play in."*

In some cases, the research reportedly would have stalled completely if it were not for the infusion of TCF funding.

TCF also provides a support mechanism for researchers who went through Energy I-Corps training, which guides researchers to better understand their technology's value proposition and comparative advantage through interviews with industry representatives (5 labs). Those PIs know their technologies' value propositions, may have potential customers, and are excited to further their technologies, but limited funding can cause their progress to stall. Being able to access TCF funds allows the researchers to leverage what they learned in the Energy I-Corps training and move their technology closer to commercialization. A Program Office representative concurred that TCF is a valuable next step for researchers who completed Energy I-Corps training.

19 The one lab who did not make an unsolicited comment in this regard reported their lab had only one TCF project at the time of the interview in 2018.

20 Nonparticipating labs are eligible to submit proposals to TCF but had yet to do so at the time of this research. Representatives from these labs were aware of the TCF program and its intent.

2.3. How TCF is Different

In addition to filling a critical gap left by other funding opportunities, as described above, lab TTO managers reported that TCF is different from other funding opportunities in a few ways: it has an explicit focus on commercialization as an outcome; its CRADA requirements are unique; and TCF has a higher cost share requirement than most other funding opportunities.

- **TCF's explicit focus on commercialization (3 labs):** The solicitation requirements force the PIs to think about their technologies' business aspects and present a commercialization strategy. Through preparing TCF proposals, PIs reportedly think about commercialization at an earlier stage in their research than they would with other funding opportunities.
- **TCF's CRADA requirements (3 labs):** Lab managers said the TCF requirement that all projects with an industry partner must use a CRADA is one they do not see in other funding opportunities. The requirement to finalize CRADAs within six months was also unique to TCF.
- **TCF's higher cost share (4 labs):** Two managers noted that the 50% cost share requirement for Topic 1 proposals was a challenge for their labs to provide; these contacts would like to see the percentage reduced. Two other managers volunteered that the industry cost share requirement for Topic 2 proposals was a good thing. They reasoned that companies willing to fulfill a one-to-one match demonstrate that they find the technology valuable; the match "keeps them honest" in their expression of interest in the technology since they are contributing their own funds.

2.4. Small Likelihood of Projects Being Funded Without TCF

If researchers' projects are not selected for TCF funding, the labs are unlikely to fund their projects. Almost all participating labs reported not funding scopes of work that were not selected by the TCF program (9 of 10).[21] Two lab TTO managers mentioned that scopes of work not selected by TCF could be eligible for the lab's LDRD funds, though they had not heard of this occurring yet.

TTO managers from labs with their own technology maturation programs said those programs could serve PIs not selected by TCF, but that had not occurred yet, except for one project at one lab. In that case, the process of preparing the TCF proposal clarified for the PI how the technology would be beneficial to industry and the PI successfully presented their case to lab management.

In the absence of the TCF program, the labs would have been unlikely to fund TCF projects. All responding lab TTO managers from participating labs (10 of 10) said that if the TCF program did not exist, the chances their lab would have funded the scopes of work submitted to TCF would be extremely low.[22] The managers from labs with technology maturation programs said that they might have funded some projects that applied for TCF funding, but that the number of projects and the funding amounts would have been lower than what TCF supports.

[21] The contact at the eleventh lab reported they did not know whether the lab had funded projects not selected by TCF.

[22] The contact from the eleventh participating lab also said they did not know the likelihood their lab would have funded the projects in the absence of the program.

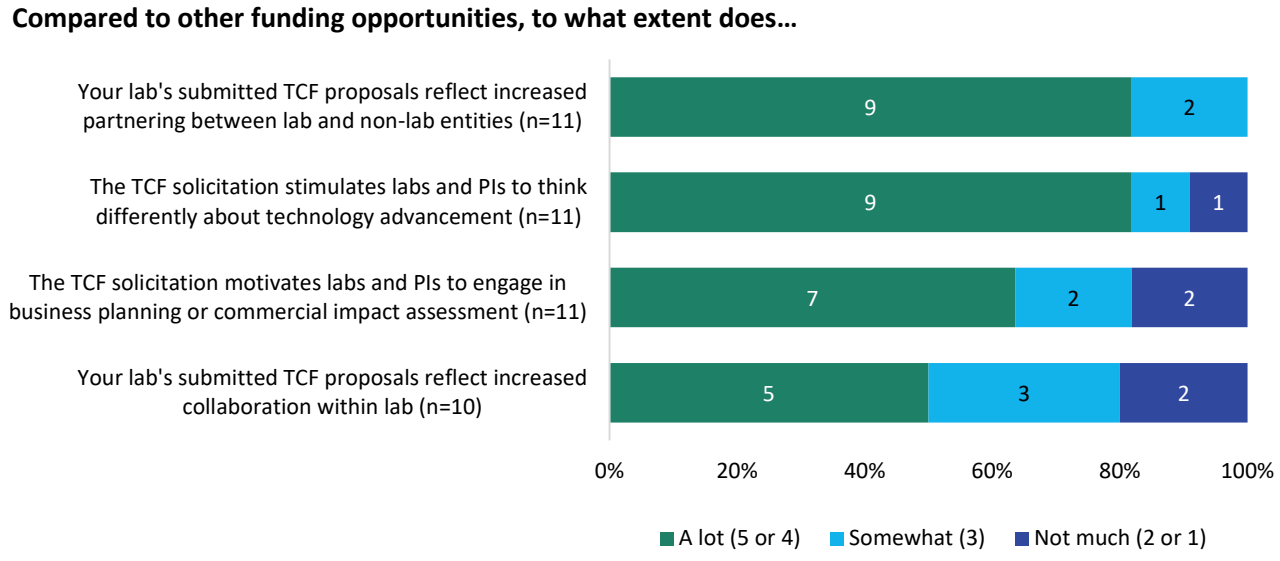
In the absence of the TCF program, the DOE Program Offices would have been unlikely to fund TCF projects. All of the responding lab TTO managers from participating labs (9 of 9) reported that if the TCF program did not exist, there was a zero to moderately-low chance that the DOE POs would have funded the scopes of work submitted under TCF.[23] Six managers reported a "zero" or "very low" chance of the POs funding the projects, and three reported a "moderately-low" chance.

Managers said this low likelihood of PO funding was because the Program Offices tend to stop funding research at the TRL 3 level. One contact from a National Nuclear Security Administration (NNSA) lab reported that they do not have programmatic connections with the DOE POs and thus don't have strong relationships with decision makers. Another lab contact said the majority of PO funding they receive is from the Office of Science, which does not support technology maturation.

2.5. TCF Program Effects

To measure how the TCF funding opportunity affects intra-lab collaboration, including thinking differently about technology advancement, we asked lab TTO managers to compare TCF to other technology maturation funding sources they use. Specifically, we asked them to rate the extent to which the TCF solicitation and resulting proposals reflect certain attributes using a 1 to 5 scale where 1 means "not at all" and 5 means "a lot" (Figure 2-1).[24] Notably, not one lab TTO manager gave a "not at all" rating when comparing TCF to other funding opportunities. Thus, the dark blue segments in Figure 2-1 represent a rating of 2. We discuss the details of these rankings in their own sections following the figure.

Figure 2-1: Program Effects of Proposal Preparation



[23] Managers from two labs said they did not know.

[24] We grouped high and low rankings to simplify the figure.

2.5.1. Increased Partnering with Non-lab Entities

TCF proposals involved more partnering with private-sector entities compared to other funding opportunities (9 of 11 labs). The program has motivated labs to develop new relationships with industry and has made the labs more connected to industry. It also demonstrated to industry partners that the labs are eager to work with them. By sponsoring the research, DOE is sending a message that it cares about commercialization and interaction with industry. One lab contact explained how the DOE cost share in the TCF program supports their involvement with industry:

> *"TCF is a great way for us to engage with industry. If the barriers for collaboration are reduced, then industry has a greater willingness to tolerate risk and ambiguity. In TCF the cost barrier is reduced because TCF has some funding from the DOE."*

Another lab TTO manager reported they are doing "two to three times the amount of work with industry as a result of TCF."

The TCF program's cost share requirements enhance the labs' need to partner with non-lab entities (3 labs). The need to secure non-federal matching funds "fundamentally forces us to get into conversations with private entities to start talking about the path to commercialization," according to one lab contact. Such engagement has allowed the labs to build a "better Rolodex of industry partners interested in our work," as another described.

Lab managers also noted how the TCF solicitation has caused PIs to seek private-sector partners more aggressively (6 of 15). Some PIs viewed TCF as a partnering mechanism that could allow them to take their technology to the next step. One lab contact described what he observed among PIs at his lab:

> *Through the course of the year, as the PIs' technologies come up against an endpoint in Program Office funding, they begin to think about who they might be able to engage in the private sector to make a compelling case for a TCF project.*

Another lab contact reported that TCF has "strongly influenced the way researchers interact with industry" because now they actively think about partners to work with during technology development.

About half of lab TTO managers (5 labs) noted that the DOE matching funds facilitates partnering because DOE support provides "a layer of credibility or advocacy" that lets the partner know that another entity sees promise in the technology; it also de-risks the partner's investment because they are not the sole source of financial support. One contact also noted TCF is open to all business types (small, large, domestic, and foreign) and all energy technology types (fossil, nuclear, and renewable) making it easier to engage industry partners for a proposal than with other funding opportunities.

The relationships formed with industry have been robust and, in some cases, ongoing. Two lab TTO managers noted that TCF partnerships with industry entities led to licensing or follow-on CRADAs or SPPs. One TTO manager from a medium-sized lab noted that since participating in TCF, their lab's number of CRADAs has gone up significantly, estimating it has nearly doubled. Lab managers described it as a success for them to have TCF-originated partnerships turned into ongoing working relationships. Others said the TCF program had benefitted them because they gained experience negotiating CRADAs, including multi-partner CRADAs.

Further, the TCF program has caused the formation of partnerships that lab TTO managers reported would have been unlikely without the program (4 labs). A contact at yet another lab made a strong statement about how TCF has encouraged greater partnering with non-lab entities:

> *"The availability of TCF funds has allowed for there to be relationships created where there were none before, or where the lack of funding would have precluded their occurrence."*

One NNSA lab mentioned that the TCF program has become an integral part of their strategy to partner with industry in the applied energy arena, an area in which they had not done a lot of partnering before. A nonparticipant lab that was preparing its first proposal for the Fiscal Year 2018 (FY18) solicitation said "we never would have worked with this company" had they not talked about the TCF-candidate technology.

The two lab TTO managers who did not rate this program effect highly said that their labs already frequently partner with non-lab entities to secure supporting funds. Two managers also noted that the Advanced Manufacturing Office's High Performance Computing for Manufacturing Program facilitates partnering with non-lab entities.

2.5.2. Increased PI Thinking about Technology Advancement

The TCF solicitation stimulates PIs thinking about commercialization and causes them to think differently about technology advancement compared with other funding opportunities.

Lab TTO managers at four labs said the TCF program was increasing PI interest in commercialization and entrepreneurship. Lab managers reported TCF has raised the PIs' awareness of commercialization activities, increased their interest in working with industry, and got them thinking about types of industry sponsors. As one lab contact commented:

> *"TCF contributes to entrepreneurial culture and the commercial awareness of the researchers in the lab, which makes us better partners with industry."*

PIs are thinking about markets and partners that they typically had not considered in the past, according to two lab TTO managers. One of them said they had seen some "out of the box thinking on who to partner with." The other said a benefit of the TCF application process is that:

> *"It has enabled inclusion of markets or industries that are not often considered in the researchers' thinking. It's gotten the laser guys to think about the electric grid. It's been eye-opening for our research staff."*

Finally, the commercialization section of the proposal forces PIs to consider their technology's financial, technical, and competitive risks and how their research might address those risks. These considerations in responding to the TCF solicitation have sparked conversations among researchers about the resources they need to bridge the gap between an early-stage technology and a product or later-stage technology valuable to the market. "With other funding sources, PIs don't even think about technology advancement and commercialization," according to another lab contact.

2.5.3. Increased Commercial Impact Assessments

The TCF solicitation motivates the lab and the PIs to engage in business planning and commercial impact assessments more than other funding opportunities (9 of 11)**.** Few other solicitations require a commercial impact section in the proposal. Those solicitations that require the PI to address the commercial impact of the technology if development is successful reportedly do not require this to the extent that the TCF proposal does.

Assessment of the proposal's discussion of the project's commercial impact composes a sizable portion of the merit review criteria, an emphasis that puts more onus on researchers to think about commercialization strategies than do other funding opportunities. One lab contact reported that for each of their TCF proposals, they have hired a consultant to assist in conducting a business opportunity analysis to inform the proposals, which they do not commonly do with other funding opportunities.

The few lab TTO managers that did not report a strong TCF influence on businesses planning commented their labs are always thinking about how to promote their technologies to make a commercial impact. They reported TCF complements their lab's existing business planning processes and TCF does not change them in a significant way.

2.5.4. Increased Collaboration within the Lab

TCF proposals spark increased collaboration between researchers and the lab TTO (9 of 10 labs).[25] The TCF proposal requirement to include a commercialization plan is a primary reason researchers are interacting with their lab TTO offices. On other funding opportunities, the PIs reportedly will attempt to complete commercial viability proposal sections by themselves without lab TTO support because those sections are not as integral to those proposals. Under TCF, researchers and the TTO worked together to develop concept papers, identify partners, and write the proposal. One lab contact at the TTO commented, "all of a sudden, the PIs were looking at us as partners in proposal development." The 10th lab commented that his lab's TTO was already assisting PIs with the commercialization aspects of their proposals before TCF and, hence, TCF has not increased it.

The TCF solicitation has not fostered intra-lab collaboration among researchers to the same extent as between researchers and the TTO. Two lab TTO managers noted increased interaction among researchers for TCF proposals, which in one case involved researchers in different nuclear directorates working together to propose a TCF application.

Those who said the TCF solicitation had not measurably increased intra-lab collaboration gave contrasting answers. On one end of the spectrum, the contact said their lab is "multi-purpose," and the researchers are used to building multi-disciplinary teams to respond to funding opportunities. At the other end of the spectrum, the other lab contact said that most of the TCF proposals have been written by a single PI and they did not notice much collaboration among researchers to respond to TCF.

[25] The contact at the 11th lab said they did not know if TCF was influencing the degree of collaboration within the lab.

2.6. Lab Changes Engendered by TCF

The TCF program engendered operational and mindset changes at the lab that lab TTO managers anticipate will increase the likelihood of future successful technology transfer. These changes fell into three main categories: strengthened TTO role at the lab; increased interest in commercialization; and enhanced PI's knowledge about commercialization. We discuss each of these in detail below.

First, we want to emphasize that the annual nature of the TCF solicitation contributes to these changes. Contacts reported the predictable cycle of funding announcements and deadlines enables them to begin identifying partners in advance and recommending PIs look into the upcoming opportunity, which reinforces lab TTO managers' and OTT staff engagement with researchers around commercialization and partnering.

2.6.1. Strengthened Role of Lab TTO

Contacts attributed TCF with strengthening the role of the TTOs. At most labs (11 of 15), PIs are primarily responsible for pursuing typical funding opportunities. With the TCF opportunity this pattern changes somewhat; most lab TTO staff were proactive in engaging researchers to respond to the solicitation (12 of 14).[26] Lab managers described actively reviewing their lab's IP portfolio to identify promising TCF candidate technologies with a high likelihood of commercialization and contacting those researchers to make sure they were aware of TCF. One lab contact estimated 75% of their TCF proposals originated from commercialization staff contacting the PI, while 25% originated with the PI independently deciding to pursue TCF.

Another lab TTO manager described the types of researchers and technologies they actively pursued as TCF candidates, which mirrored the responses of other contacts:

- Researchers who expressed interest in TCF in the past,
- Researchers who started a TCF proposal and did not finish it,
- Researchers who have won R&D 100 awards,
- Technologies with LDRD funding that are nearing completion, and
- Technologies at TRLs 3 or 4 that lack funding and need additional development to attract industry interest.

Lab TTO managers credited the TCF program with giving them a "talking point" with which to approach lab researchers, which broadened their ability to engage with PIs. One described TCF as a "cherry" that enables them to approach PIs to let them know there is money available for technology maturation. TCF availability led to commercialization conversations that previously did not occur or were more limited. These conversations increased PIs' awareness of the lab TTO and fostered greater collaboration between them because PIs came to view the TTO as a strategic partner in proposal development.

[26] At two nonparticipating labs, the TTOs or Partnerships Offices mostly pursue funding because of the nature of the research – high energy particle physics and plasma physics. In these cases, the labs need to secure substantial amounts of partnership funding (for example, $10 million) to support multiple researchers and lab management does not think it makes sense to have individual PIs apply for small amounts of funding.

For example, one lab contact described how his office engages with PIs around the TCF opportunity:

> *"To the extent that we see technologies under development that look like they might benefit from either a Topic 1 or 2 offer from TCF, that is something that we might bring up to PIs, whereas previously we might not have. So, very much, we look to have commercialization conversations, make TCF a priority, market it internally, answer PIs' questions, and get them to take this seriously."*

One lab TTO contact expressed how his thinking has changed because of the recurring TCF opportunity. He said that lab commercialization managers "need to be cognizant of what their IP portfolio looks like, and ask themselves 'what has the best opportunity to be commercialized?'"

2.6.2. PIs Learned about Commercialization

Through participating in the TCF solicitation, PIs have learned more about the commercialization process and how to position their technologies to make them attractive to industry partners (9 labs). Increased collaboration between researchers and the lab's TTO or business development staff has been one source of this learning (4 labs). Managers from seven labs used the term "eye-opening" to describe the impact that TCF has had on PIs' thought-processes and interest in commercialization.

As we discuss in section 3.2.7, it was new for many PIs to think about their technologies from an industry perspective. Prior to TCF, PIs had a "build it and they will come" mentality, as two managers stated. Since TCF, PIs have learned the elements that go into a commercialization plan and how challenging it can be to make a compelling case for their technology. Thanks to TCF involvement, lab TTO managers noted some PIs have learned what they can use to demonstrate their technology's commercial viability, including commercial metrics such as cost, durability, and failure rates.

Lab TTO staff also report successes in helping PIs recognize when an innovation is patentable and how they need to engage with the TTO to file a disclosure when they have an invention. Having PIs aware of this process is important because the IP then can be leveraged through the TCF program to attract industry investment.

Importantly, lab TTO managers said the TCF-engendered thought processes are transferable to other technologies on which the PIs are working (5 labs). Once PIs were aware that TCF is a recurring opportunity, they reportedly began to think of TCF as a tool they can use to advance their technologies. Some PIs considered how to position their other projects as something that could be eligible for TCF funding and allow them to partner with industry. Also, through engaging with industry, the PIs are learning what their target industry needs and finds interesting, and the PIs can apply that knowledge to their other technologies under development. One lab contact commented on this learning:

> *"In the process of submitting the proposal, they are interacting with industry. That also increases the likelihood of successful commercialization because now they're thinking more about what industry values."*

The TCF solicitation caused PIs to think about the commercial potential of their technology, what steps and resources they need to successfully commercialize their technology, and how to protect their IP, according to contacts.

2.7. DOE Program Office Changes Engendered by TCF

In contrast to what we heard from the lab TTO managers, the DOE Program Office managers did not report significant spillover effects to their thinking or funding allocation processes. The PO managers said that their offices regularly encourage partnering with the industry. However, two PO managers noted that TCF's Topic 2 requirements to have a CRADA with an industry partner has increased the number of CRADAs in their offices' portfolios.

DOE contacts reported that one of TCF's unique aspects is that it gives the labs more opportunity to propose funding technologies they believe will have the greatest commercialization potential (3 of 3 PO contacts and 1 of 2 TO contacts). This lab opportunity is consistent with TCF's enabling legislation, which Congress designed intending to limit government push. Typically, when the POs issue funding announcements, they are focused and targeted to specific technology goals and roadmaps. TCF's structure, on the other hand, requires the POs to fund all applied energy research and development projects deemed meritorious by the independent reviewers, subject to budget availability and program policy factors.[27] The PO and TO managers described this as a good thing, and one said that the result is that their office is seeing projects from the labs through TCF that they might not see otherwise.

The Program Office representatives said that their experience with TCF has not influenced the way they allocate funds in their other activities. If anything, guidance from the current presidential administration affects their decision-making criteria for allocating funds (2 of 3 POs). While TCF has not necessarily changed the way they view their portfolio or what constitutes a promising technology, two contacts (1 PO and 1 TO) said that the recurring TCF ensures that there is, at least, a basic level of support for commercialization at the Program Offices.

A representative from another Program Office added that staff members have more "insight on commercialization" now that the TCF projects are part of the PO's portfolio. For example, one manager with a TCF project in the portfolio learned about using open-source software codes to create commercial packages sold to industry, and the research manager now recognizes how TCF bridges development work until industry can pick it up.

[27] TCF funds only meritorious proposals, however not all meritorious proposals are funded.

3. Process Evaluation

The process evaluation assesses TCF program processes in FY16 and FY17. It includes data from interviews with managers at DOE's OTT and Program Offices, lab TTO managers, PIs, and Partners. The chapter's organization roughly follows the participation process (Figure 3-1): solicitation release, proposal preparation, the review process, notification of awards, and the execution process. It ends with a short section on additional considerations.

Figure 3-1: The TCF Participation Process

3.1. Solicitation Notification

OTT issued a solicitation to the DOE national laboratories, which outlined the proposal requirements, submission process, and due dates. This section presents the process PIs and lab staff take in advance of preparing the proposal.

3.1.1. PI Interest in Applying for TCF

Most PIs reported a high degree of interest in the TCF program among their lab colleagues (7 of 9). PIs were appreciative that the TCF program exists, recognizing that in the past there was a lack of support, funding, and opportunity at the national labs for PIs to commercialize technologies and partner with private industry. PIs said interest was particularly high for researchers working with higher-TRL technologies and those working on more applied research.

At the same time, two of the PIs who reported their colleagues were enthusiastic about TCF, said that their level of interest is still not as high as for other DOE funding opportunities, largely because TCF Topic 2 requires an industry partner, which can be difficult and time-consuming for PIs to obtain. Two other PIs said that PI interest in TCF at their labs is low overall because of their labs' focus on R&D projects and that few researchers have projects or interest in pre-commercialization development.

3.1.2. Letter of Intent

Requiring a Letter of Intent (LOI) had unintended negative consequences for the Program Offices and positive effects for the labs. In FY17, OTT required PIs to submit an LOI prior to submitting a proposal. Any PI who submitted an LOI could submit a full proposal. The LOI's primary purpose was to inform the DOE Program Offices of the technology areas for which project teams were planning to submit

proposals. The advanced notice allowed the Program Offices time to identify and recruit reviewers for the expected proposals.

In FY17, the number of LOIs exceeded the number of proposals submitted, nearly two-to-one. This discrepancy caused the DOE Program Offices to unnecessarily recruit reviewers with expertise in specific technology or market areas. Some PIs reportedly used the LOI as a "placeholder," so they could later decide whether they wanted to submit a full proposal. Because of the unnecessary work caused by recruiting unneeded reviewers, OTT removed the LOI requirement for FY18 and replaced it with a "concept paper" requirement that asked for more details than the LOI. OTT also waited to recruit reviewers until after they received all proposals in FY18.[28]

The letter of intent provided secondary benefits for lab staff and PIs (9 of 11 labs). Having PIs prepare LOIs gave lab commercialization and technology transfer staff a sense of how many proposals their lab would be submitting, and in which technology areas, giving them time to align resources to support those proposals (6 of 11 labs). One lab representative working in an office for science and technology partnerships explained how the LOI helped him:

> *"When we get early visibility into solicitations and who is interested, that is helpful for us to know how many PIs may apply. The earlier we get involved in that part of the process, the more helpful it is for us to make sure that we are aligning our resources to support those efforts."*

Aligning resources also included identifying matching funds. Managers at one lab mentioned that the LOI process informed them of how many Topic 1 proposals the lab might submit, enabling them to gauge whether there were enough royalties to fund the match. The exercise of estimating lab matching funds informed decisions in a down-select process to limit the number of Topic 1 proposals submitted.

Managers from seven labs reported that the LOI process also gave PIs an initial, low-effort opportunity to outline their project and think it through before writing the full proposal. The extra time built in for the LOI also enabled PIs to reach out to their industry managers and start a discussion with them about partnering prior to writing a full proposal (5 of 11 labs).

A minority of labs (n=2) had negative feedback about the LOI process. One lab representative reported the process was not valuable because they did not receive any feedback on the letters they submitted. The other said that it forced them to decide on which project teams would pursue TCF funding earlier than they would have liked, and as a result, suggested PIs at their lab submit a letter as a placeholder so they would not be excluded from submitting a full proposal later, consistent with reports from OTT and Program Office contacts.

[28] OTT, through ORISE, began reviewer identification in response to concept papers received. Hard recruiting began with OTT's receipt of the proposals. The current evaluation covers FY16 and FY17. We do not have feedback on the FY18 procedures.

3.2. Proposal Preparation

This section reviews whether the solicitation gives PIs enough time to recruit partners and prepare proposals, how labs fund their match for Topic 1 proposals, who is involved with proposal preparation, questions project teams had after reading the proposal solicitation, how adequately the proposals described commercial viability, and the submission process.

3.2.1. Adequancy of Response Time

Contacts appreciated the longer second-round (FY17) proposal response time; the shorter FY16 response time made building relationships with new industry contacts challenging. In FY16, project teams had just under two months to submit their proposals after OTT released the solicitation. OTT extended the proposal preparation window to nearly two and a half months for FY17 in response to lab feedback that mirrors our findings below.

In general, most lab TTO managers reported that the notification provided enough time to find interested partners and write the proposal (8 of 11), but that it was also a challenge to build relationships with industry in that time (7 of 11).

The timing was particularly tight for PIs submitting Topic 2 proposals, which require a 50% cost share from an industry partner. Lab managers reported that 50% of the project total was often a substantial amount of money and they needed time to develop relationships with partners before asking them to sign a letter of support committing funds should the proposal be selected. One lab contact noted that the short amount of time in the first round limited them to write proposals with partners that were already engaged with the lab, which they understood contradicted TCF program objectives.

Two interviewed FY17 PIs mentioned challenges related to OTT issuing the solicitation in advance of the winter holidays. They said it was a "tight turnaround" to get the LOI submitted before the winter holidays and was harder to coordinate with colleagues and industry partners who were traveling during that time.

The solicitation was issued on February 4, 2016 for FY16 and on November 29, 2016 for FY17. Lab managers suggested that consistent timing of when OTT issues the solicitation each year would help them to do "pre-planning" and start building the necessary relationships with industry partners (n=4). Lab managers appreciated when OTT informally communicated to them when it was anticipating releasing the solicitation.

3.2.2. Approach to Finding Partners

The labs were divided in their approaches to finding partners: half the labs (5 of 11) relied almost exclusively on PIs to leverage their connections with industry, many of which were longstanding, while the other half (6 of 11) had TTO staff proactively involved in making connections with partners.

Lab managers in the former group said that PIs generally had existing relationships with industry, had an idea of whom to partner with, and made the initial contact. Labs managers in the latter group have commercialization or technology transfer staff who review their lab's patent applications and intellectual property to assist PIs with identifying partners or otherwise advise PIs on suitable industry partners. Managers from two labs said they post a federal partnership opportunity notice on their website, as well as promote the TCF opportunity to partners they encounter at the lab, conferences, or technology exhibits.

Labs' approaches to finding partners differed between Topic 1 and Topic 2 projects. Four labs did not pursue partners for Topic 1 projects, while the other interviewed labs did. Lab contacts reported it was easier to attract industry partners to Topic 2 projects because the value proposition for partnering was clearer. Another contact described how the lab's Topic 1 partners were identified by lab staff conducting market research, while Topic 2 partners were identified by PIs who have engaged in some customer discovery.

One lab TTO manager described unique, lab-specific circumstances that made it challenging to engage industry partners on TCF proposals because industry groups experienced in partnering with that lab had reportedly grown accustomed to funding opportunities that do not require a cost share and were unclear about TCF's purpose.[29]

All three interviewed industry partners reported a longstanding relationship with the national labs and had previously collaborated with lab researchers on other DOE funding opportunities. One partner reported learning about TCF through a funding opportunity announcement and the other two said their firms have contacts at the labs through which they learned about TCF. All partners reported interest in accessing lab resources and in the technology's potential contribution to their company as a motivator to apply for TCF. The 50% cost match provided by the federal government also factored into industry partners' decisions to apply for TCF.

3.2.3. Funding the Match

All labs with royalties use them to provide the 50% cost match for Topic 1 projects, and most of these labs established a formal process to select which technologies to propose to TCF. For Topic 1 projects without an industry partner, the labs supply the 50% cost match to DOE funds. Labs cannot use funds from other federal contracts and thus used royalty funds earned from licensing patents (9 of 11). The other two labs reportedly do not have lab funds to use and all their matching funds came from private industry partners; one of these labs was a government owned, government operated lab.

All nine labs using royalty funds mentioned that those funds are limited and there is high demand for them, making it challenging to rely on those funds to fulfill the cost share. Four lab TTO managers

[29] This contact believes the issue is unique to their lab due to the nature of their relationships with private sector firms.

reported that a 50% cost share was onerous and that other programs, including the Small Business Voucher program, have lab cost share requirements of 20%, which they described as more reasonable. One interviewed industry partner also mentioned that the firm's experience with other DOE funding opportunities that required a 20% cost share led it to conclude that the TCF was not particularly "lucrative." This industry partner also felt the 50% cost match requirements might be difficult for start-up companies to provide.

Managers from two other labs, in contrast, mentioned that they have had success in justifying to lab management spending royalty funds on a TCF match because the royalties are promoting commercialization activities likely to lead to future royalty money. One of these managers explained why his lab appreciates the TCF program. He said,

> *"We have always used our royalty funds to reinvest in technology maturation, but now with the TCF program, we double that money because of the DOE match."*

Given limited royalty funds, all interviewed labs that do a match from lab funds (8 of 8) reportedly have an internal, down-select process to limit the number of Topic 1 proposals they submit to TCF. At four of those seven labs, a lab director or committee makes the final approval decision on which proposals to submit. The fifth lab limits its Topic 1 submissions by prioritizing those projects that fit with their internal technology maturation program.

The sixth lab had multiple staff and a subject matter expert review each of about TCF 20 proposals to ensure that there was IP involved and that an influx of capital would help push the technology to market. That review process limited its Topic 1 proposals to use "precious lab cash for the projects we really think are going to move forward." Lab managers at the seventh lab described a similar process involving multiple staff reviewing proposals to ensure there was IP and a high likelihood that TCF funds would lead to TRL advancement. Managers at the eighth lab anticipated about half of their proposals would be selected for funding and calculated they could afford to fund three Topic 1 projects. The lab asked their PIs to prepare a two-page "mini-proposal." They received 30, which the lab's division directors reviewed to select the six Topic 1 projects to submit to TCF.

3.2.4. Topic Funding Amount

Representatives from all 11 labs reported that the topic funding amounts were appropriate given TCF's objectives for each topic. Three lab TTO managers wanted to see the overall TCF budget increased so that more PIs could participate in the TCF program.[30]

3.2.5. Involved Lab Staff and Process

Interviewed PIs appreciated the administrative support they received from their labs to address the non-technical parts of the proposal and ensure they were meeting all the solicitation requirements. PIs said this allowed them to focus on the technical and scientific components of the proposal, while ensuring overall quality and responsiveness.

[30] To date, DOE has limited the overall funding amount to that required by statute: 0.9% of the applicable applied research budgets.

Contacts at all labs reported the PIs and their teams led proposal preparation, but most labs (8 of 11) also have staff to assist with technical editing, reviewing, and gathering supporting documents to ensure high-quality proposals that are responsive to TCF's solicitation criteria. They also checked for consistency between the proposal sections and consistency between the budget and proposed scope. One lab TTO manager mentioned that the lab's financial staff help put the budget together. The supporting staff tend to reside in the labs' technology transfer department, technology deployment office, technology and partnerships department, or have business development titles.

3.2.6. Common Questions

Contacts appreciated the clarified cost-sharing information and the Q&A process in the FY17 solicitation; questions remain whether to apply as a Topic 1 or 2. After reading the solicitation criteria, PIs and supporting staff at all 11 labs had clarifying questions about the cost-sharing requirements, particularly about what qualifies under the cash and in-kind categories. In FY16, there was no minimum stipulated for a partner's cash contribution, which led some PIs to question whether $500 was sufficient or whether proposals with greater cash contributions would be judged more favorably. Others had questions about whether equipment purchases made by partners counted as cash contributions or in-kind funding toward the 50% matching requirement (n=3). In the FY17 solicitation, OTT stipulated a $10,000 cash contribution to clarify the cash contribution requirement. Even so, two interviewed FY17 PIs reported that cost match requirements were unclear and encouraged OTT to have more descriptive language on what qualifies as a cost match for TCF.

Other questions PIs had included whether they should apply for Topic 1 or Topic 2, and whether they should bring in a partner or not (n=6). One interviewed PI questioned the level of market analysis and commercial viability required for a Topic 1 technology given that Topic 1 awards are for technology maturation. The same PI was also unclear about which topic to select for a "mature Topic 1" technology.

Some PIs asked whether international companies qualified to be the industry partner, whether companies that had established "umbrella CRADAs" with the lab could participate, and whether a company with an existing CRADA could partner with a lab team for a new technological application on an existing patent. Finally, lab TTO managers reported that some of their PIs questioned which technology areas they should select for their projects (n=3), whether they needed to have IP created to apply for TCF (n=3), and what the TCF win rates have been (n=2).

OTT developed a question and answer (Q&A) process in FY17 to make sure teams at each lab had the answers to any question asked. Without being prompted to discuss the Q&A process, representatives from five labs mentioned that it was helpful to have the clarified proposal solicitation criteria and that DOE was responsive during this process.

3.2.7. Commercial Viability Content

All contacts – labs, PIs, and partners – are pleased with TCF's commercial viability requirements. Managers from all labs (10 of 10) reported that the proposal requirements around commercial viability and approach to commercialization were appropriate and prompted the labs to provide information

useful for an assessment of commercial viability.[31] All nine interviewed PIs reported the merit review criteria – technical maturation and commercial impact – were appropriate given TCF's objectives.

The two interviewed partners who contributed to proposal drafting expressed satisfaction with the merit review criteria. These partners contributed on other DOE proposals, and while they acknowledged that TCF had a greater emphasis on commercialization compared to other opportunities, they thought the criteria were pretty typical and common. Both respondents reported experiencing no issues or surprises.

Lab managers and four interviewed PIs expressed that having a strong commercialization section in the proposal was particularly important given TCF's objectives. As one lab contact explained:

> *Commercial viability should be the foremost factor in this type of funding. We have funding for all sorts of other research that doesn't factor in commercial viability to any significant degree. TCF is all about commercializing technologies, so it is paramount to the entire decision.*

One partner also expressed support for TCF's commercial impact criteria, as it helps to reassure private industry that there is potential for the technology and that it should be supported.

Clarifying paths to commercialization for their technologies is not lab researchers' strong suit. Researchers needed help thinking through and writing a strong commercial viability section in their proposals (11 of 11 labs) and that was a primary reason the labs chose to involve their technology transfer offices in supporting proposal development. Lab managers noted that PIs focus on technical feasibility and performance and may not be aware of how the market might receive the technology. Five interviewed PIs mentioned that their focus on early-stage R&D means they do not spend much time thinking about commercial impacts and sometimes had to make their best guess on commercial viability. Eight lab TTO managers noted that PIs who have gone through Energy I-Corps training are better positioned to address commercial viability in their proposals.

Based on our understanding of the Energy I-Corps training curriculum and its emphasis on customer discovery, we asked lab TTO managers whether they thought it would be useful for the proposal solicitation to include a requirement that PIs engage in some customer discovery to clarify commercial viability in their proposals. Lab managers did not recommend making customer discovery a proposal requirement because of the time and effort involved (10 of 10 labs), though eight understood the value of customer discovery activities. Lab representatives mentioned that Topic 2 researchers already have a committed industry partner and that it might be premature to do customer discovery for Topic 1 technologies, which are early-stage. Managers from five labs said that if customer discovery activities became a proposal requirement, their lab's number of submissions would drop.

Most lab TTO managers (8 of 10) thought that requiring the proposed work scope to include customer discovery made conceptual sense, but in practice would need to be accompanied by a budget that includes customer discovery activities. Other lab TTO managers reported that if such a requirement were introduced, they would not want it to have rigid specifications, but rather be more of a general requirement about market research rather than customer discovery specifically. One lab contact

[31] Managers from the 11th lab reported they did not know how appropriate the proposals requirements were or whether they provided information useful for reviewers.

questioned the appropriateness of such a requirement for Topic 2 technologies since they already have a partner on board. The industry partner might view customer discovery activities as engaging that partner's competitors.

3.2.8. Selection of Technology Areas

Refinements to the FY18 solicitation helped PIs select appropriate proposal technology areas; the treatment of technology area in the FY16 and FY17 solicitations had some PIs confused, added burden to the proposal review process, and resulted in unintended negative consequences for a few applicants. In the FY16 and FY17 solicitations, OTT listed the technology areas, but did not provide a description of them. Many of the technology areas are narrowly defined and specific. The Program Offices posted descriptions of these areas on their websites, but it appeared that many PIs did not take the extra step of going to the website to learn the specifics to determine if their proposal was a good match for that technology area. This led to some proposals not being a good fit for some of the technology areas the PI selected.

For each technology area the PI checked, an area-specific reviewer scored the proposal. OTT and PO contacts noted that sometimes proposals with multiple technology areas received poor scores from the reviewers of the technology areas for which the proposal was not a good fit. DOE recognized this mismatch and instated changes to improve the selection of technology areas in subsequent solicitations.

In FY16, PIs could select as many technology areas as they wanted to when submitting their proposal, with some reportedly selecting up to seven areas. In FY17, OTT limited PIs to selecting three technology areas. Still, some PIs selected up to three areas, not all of which were a good fit for the proposal. Continuing the refinements, the FY18 solicitation included short descriptions prepared by the POs of the desired technology areas. During interviews in early 2018, some lab TTO managers reported they appreciated the extra elaboration to clarify precisely what the POs were looking for in the specific technology areas.

Other lab contacts mentioned how selecting a technology area has affected their program participation. Researchers at NNSA labs have found the technology areas limiting since they do not engage in much applied nuclear energy research and prioritize nuclear security research. Managers at National Renewable Energy Laboratory noted their PIs are limited to Office of Energy Efficiency and Renewable Energy (EERE) technology areas, which understandably limits the potential funding available to them. In contrast, contacts at another lab ascribed some of their success with their TCF proposals to applying under a Program Office with "deep pockets."

3.2.9. Submission Process and INL Portal

Most contacts were satisfied with the proposal submittal process and INL submittal portal. In FY16, project teams submitted proposals via email. In FY17, project teams submitted their proposal through an online portal maintained by the Idaho National Lab (INL). A TCF project coordinator at INL reported no problems with the uploads and submissions to the system. One interviewed PI reported that after learning how to create an account through the INL portal, the process of submitting the necessary documents was straightforward. DOE Program Office managers did not have much insight into the submission process but understood the process to be satisfactory.

Managers from most labs (8 of 9) reported that the TCF submission process was either less difficult (5) or comparable (3) to other funding opportunities.[32] Their reasoning was that it was easy to submit through INL's electronic portal (4), the proposal format and budget template were well-received (2), and that the five-page proposal length – shorter than many other opportunities require – did not take too long to prepare and encouraged PIs to focus their message (2). One PI commented on the proposal length saying that it was at the right level because any longer would cause overhead problems for the partner to prepare their portion of the paperwork and any less would not provide reviewers with sufficient information. One industry partner added that applying to TCF was "easy relative to other DOE grants."

No one reported issues with sharing proprietary data in the proposals. The proposal instructions were clear; teams marked any proprietary data as such and no contacts found that problematic.

One lab TTO manager reported TCF submission as more difficult than other funding opportunities because they found the online portal cumbersome since it required uploading more than one file and typing information into fields.

3.3. Proposal Independent Review Process

The review process first involved external reviewers scoring the proposals on technical merit and commercial viability. Then, staff from the DOE Program Offices reviewed those scores and had the opportunity to adjust the ranking for compelling reasons. After that, there was a one-day meeting where representatives from the TCF-participating Program Offices came together to decide on the selection recommendations. Finally, the Selection Official (a senior DOE official) approved the Program Offices' recommended projects. We elaborate on each of these steps below.

3.3.1. External Reviewers and Their Performance

3.3.1.1. Reviewer Recruitment

The reviewer recruitment process encountered snags; OTT revised the recruitment process for FY18. In FY16 and FY17, the DOE Program Offices (and Technology Offices in EERE) had responsibility for identifying reviewers for their technology areas. Each proposal required a minimum of two technical reviewers and a commercialization reviewer. Per TCF procedural requirements, reviewers needed to be in the United States when they conducted the review and could not be DOE employees or contractors, although federal employees and contractors from other agencies were eligible reviewers.

OTT staff reported they thought they had sufficiently explained to Program Offices that the POs should recruit the reviewers they had identified for each proposal and requested that no more than five proposals be assigned to any single reviewer. As the review process unfolded in FY16 and again in FY17,

[32] One contact did not know how the submission process went because the PIs at her lab submitted the proposals and the other did not address this question.

it appeared that some identified reviewers had not been formally recruited by the POs and thus had not agreed to review proposals.

This situation became critical in FY17 when OTT staff emailed the recruited reviewers to provide specific details on dates, next steps, and a reviewer training. Some reviewers replied saying they had not agreed to review TCF proposals and did not know to what OTT was referring. OTT did its best to salvage those contacts and maintain them as reviewers, but in FY17 had to use the Oak Ridge Institute for Science and Education (ORISE) to identify and obtain replacements for some reviewers who were unwilling to conduct a review or were out of the country during the review period.

Representatives from DOE Program Offices we spoke with relied on existing lists or stakeholder registries they maintained to recruit TCF reviewers. Program Office staff did not report challenges to recruiting reviewers, except that one office mentioned they had two open Funding Opportunity Announcements (FOAs) at the same time they were recruiting reviewers for TCF, so "it got a little hard" for them to ask their small pool of reviewers to look at more proposals. This office said they came close to not recruiting enough reviewers due to the simultaneous call for proposals but did not anticipate that this would be a recurring problem. Once recruited, the Program Offices supplied the lists of reviewers to OTT staff.

For FY18, OTT used ORISE to recruit all reviewers. ORISE maintains a large database of reviewers across myriad technology areas and has substantial experience in recruiting reviewers on behalf of DOE. At the time of the interviews, OTT staff anticipated that ORISE will be able to recruit in a timely manner and ensure the reviewers understand their assignments.

3.3.1.2. Reviewer Training

In FY17, OTT conducted a webinar training for the reviewers. It explained how to access INL's portal where the proposals were stored, explained the solicitation and merit review criteria, and reviewed the scoring methodology, describing the meaning of each rating value (such as a "9") to ensure reviewer uniformity. The training also provided resources and contact information to address reviewers' questions. OTT provided reviewers with a recording of the webinar as well as written step-by-step instructions.

OTT and Program Office staff assessed the training as satisfactory and effective in preparing the reviewers for their task. OTT staff planned to maintain the reviewer training for FY18.

3.3.1.3. Quality and Timeliness of Reviews

Contacts reported that, overall, the technical reviewers had the proper technical expertise to accurately judge the proposals. After looking at their proposals, a small number of reviewers communicated with OTT that they were not appropriate for that technology and suggested someone else. In one case, instead of identifying that he was not a qualified reviewer, a reviewer scored the proposal with all zeroes and commented that he did not have sufficient expertise.

Commercial viability reviewers also largely had the requisite expertise to accurately judge the market impact and commercial viability proposal sections, according to contacts. One Program Office representative noted that some of their commercialization reviewers were not sufficiently familiar with the main types of customers for the Office's technologies.

Program Office representatives reported the overall quality of the external reviews was good – both technical merit reviews and commercial viability reviews. One Program Office representative described the quality of reviews to be "average to above average" compared to other proposal reviews they had seen.

There were few large discrepancies among scores provided by the multiple reviewers of a proposal – one OTT staff representative estimated 10% or fewer of proposals had discrepant reviews. When there were major differences in a proposal's scores, the Merit Review Committee discussed the discrepancies and was responsible for their resolution.

Most reviewers submitted their reviews on time. A small percentage had not submitted their reviews by the deadline. Program Office and OTT staff commented that some stragglers are always to be expected and given that the reviewers were not compensated for their time, OTT staff were not troubled by the small number of delayed reviews. OTT staff had built in a week or two of contingency time for stragglers and therefore the external review process concluded in a timely manner.

3.3.2. Program Office Reviews

After receiving the merit review scores and resolving any substantially discrepant scoring, the Program Offices ranked their proposals. OTT staff reported that the Program Offices each conducted their rankings differently. Some Program Office representatives reported receiving the external reviewers' scores while others said they did not see the numerical scores, but only the proposal ranking (highest-scored to lowest-scored).

The Office of Electricity and Office of Nuclear Energy Program Offices assigned proposal ranking to appropriate technology experts in their Offices and then those experts collectively created a final ranked list. The EERE corporate office used its Information Management process to request feedback from the Technology Offices on the proposal rankings. Even though participation was optional, EERE reported broad participation from the Technology Offices; each one gave feedback in 2017 and all but one gave feedback in 2016.

Program and Technology Office staff could ask questions about the merit review results and adjust the ranking of the proposals based on their recommendations and office preferences. At the end of the Program Office reviews, each Program Office had a ranked list of the proposals they wanted to fund.

3.3.3. One-Day Merit Review Committee Meeting

The one-day Merit Review Committee meeting with decision-makers from the Program Offices and OTT went smoothly in FY16; the FY17 recommendation decisions encountered a small delay occasioned by one of the Program Offices, and a much longer delay occasioned by lack of DOE executive direction concerning funding from ARPA-E.

Once the Program Offices had developed a final ranking of proposals they wanted to fund, the TCF Working Group members from each office and OTT convened for a one-day meeting to choose the projects that would be recommended for selection for TCF funding. Working a Group members came prepared with the feedback from their staffs.

Everyone received a binder with all proposals and each Program Office announced the number of proposals they received and confirmed the funding amount they could allocate. They discussed and negotiated which projects they would fund. Some Program Offices jointly funded proposals with cross-cutting technology areas. In other cases, one Program Office would fund a cross-cutting proposal of particular interest to another Office, enabling the latter Office to select another proposal.

One Program Office representative summarized the negotiations at the one-day meeting:

> *Each Program Office presented their case and it was pretty straightforward. But there was some give and take and discussions until we understood how much money each Program Office had spent and how much money was left over. All in all, it went well and was pretty quick.*

Both in FY16 and FY17, a Program Office representative reportedly had not been authorized to make decisions on behalf of the Office and had to bring the materials back to a senior DOE official. The Director approved the proposals, and the recommendations were finalized. This situation did not cause a long delay, but one OTT staff said it is far preferable for selections to be finalized at the end of the one-day meeting.

3.3.4. Selection Official

Final selection of recommended proposals was uneventful. The last step in finalizing the list of selected proposals was approval by the DOE Selection Official. TCF staff from OTT presented a Merit Review Committee report and selection statement, which included the list of proposals recommended for selection at the one-day meeting. The Selection Official asked clarifying questions on some projects, and generally supported the decisions made by the Merit Review Committee.

3.4. Selection Notification

This section discusses how the Program Offices notified selected PIs of their selection and distributed funds. We also discuss the how helpful or useful the reviewer comments were to selected and nonselected PIs.

3.4.1. Notification Process and Timing

Labs and PIs expressed dissatisfaction with what appeared to them to be a disorganized notification process. In FY16, OTT TCF staff notified the PIs and the labs of the selected TCF proposals via email. The email asked them to keep the information secret until the DOE made a public announcement. OTT also notified the Program and Technology Offices that the selections were being announced and that the Program Offices could transfer the funds to the labs. Since Program and Technology Offices transferred their funds independently, there was some variation in how each did that, as reported by lab TTO managers. The variation in receiving notification and funding caused challenges for lab licensing staff, TTO staff, PIs, and project partners.

First, TCF notifications did not always go to the TCF program contact at the lab, which typically was the lab's TTO, licensing, or strategic partnerships office. At seven labs, the PIs were notified before the lab's TCF point of contact and most lab TTO managers were displeased about that (6 of 7). At two labs, PIs were reportedly notified first on some projects and the TCF program contact was notified first for other projects.

Second, selected PIs were notified at various times, causing confusion (4 labs). When some PIs had heard their results and others had not, the PIs who had not heard typically worried and reached out to the TCF point of contact. TCF points of contact who likewise had not been notified of the selections were unable to answer the PIs' questions. At one lab, a PI in this situation wondered if their proposal "fell through the cracks" and ever got reviewed. As one lab contact said, "It would be useful if the TTO was copied on all announcements that went to the PIs so there could be a collective understanding and so we can inform senior lab managers."

One reason the TTO offices want to be notified in a timely manner is because they want to start CRADA negotiations as soon as possible. Since CRADA negotiations take time and TCF requires completion in a six-month window, it is important that the TTO begin CRADA negotiations as soon as possible. One contact we spoke with explained his dissatisfaction with the notification process:

> *"Broader notification generally helps us make sure to initiate a sequence of events that have to happen. The release of funds varied widely by programs [Program Offices] and that caused some tactical issues around when PIs were able to start projects. There was a lot of confusion of when the funding would actually arrive and how it would arrive."*

Third, funds from the Program or Technology Offices arrived at various times as well, according to managers at three labs. At two labs, contacts described that the money arrived, and no one knew who it was for or that it was TCF funds because there was no simultaneous communication from the Program Office. At another lab, some projects received funding before their CRADAs were finalized and they were not sure what to do with the funds, while other projects finalized their CRADAs and had yet to receive their money. In the latter case, not having access to the money delayed project initiation.

This variability in when funds reached the lab was reflected in the answers lab TTO managers gave when we asked them how long after selection notification their labs received the money. The most common answer was that "it varies by PO;" an answer given by three lab representatives. Other answers ranged from "within a few weeks," and "about two to three months," to "more than six months."

Lab managers from seven labs were dissatisfied with the communication from OTT and the DOE POs following the announcement of selections. Several noted that communication from these offices during the solicitation was fantastic with the webinars, Q&As, and timely response to emails. Yet, during the project execution phase, it was not clear to lab representatives who they were supposed to contact at the Program Offices and some reported that emails to OTT went unanswered. One of these managers suggested a better "hand off" between OTT and the funding Program Offices so that it was clearer to the labs to whom they should address questions and with whom they would be working at the Program Office. Some were unclear whether they were to report to OTT or if all reporting goes to the funding Program Office once projects started.

3.4.2. Announcement Delay in FY17

Labs and PIs noted negative consequences, both potentially and in fact, from the FY17 announcement delay. Many lab TTO managers and PIs mentioned the delay in the announcement of selected project teams in 2017 (7 of 11 lab TTO managers; 5 of 9 PIs). The delay negatively affected partners and PIs. PIs submitted their proposals in February 2017 and had been told to expect to award results in the spring. Most PIs reported receiving notifications mid-August.

Four lab TTO managers noted that the announcement delay negatively affected industry partners. They mentioned that industry "moves quickly" and many things can change in the time they are waiting for the TCF results, including their business models, management, and priorities. The industry partners make plans to set aside their cost share funds and can be excited to work with the labs. Managers at two labs mentioned how announcement delays affect their industry partners:

> *"If you leave the industry partner hanging out there too long, interest wanes sometimes."*

> *"When these delays happen it certainly has a significant impact on the industry partner's commitment to moving forward."*

The experiences of one interviewed PI supported these comments. The PI reported their partner was pursuing a new business opportunity through TCF. The delay in award announcement frustrated the industry partner and the partner cut off contact with the PI, insisting on no further communication until the PI knew whether they had been awarded the funding.

Delays in announcing selections delay the start of CRADA negotiations, which also delays commencement of the work. A third lab TTO manager said the following:

> *"Once you're awarded TCF funds, that CRADA needs to be in place pretty quickly. We kept trying to engage our partner and get them ready for that CRADA to come out. It's just more frustration that we were in a holding mode before we could get anything done."*

Two lab TTO managers described how PIs expect a decision within a certain amount of time, and if they have not heard results within that time, they would assume they were not selected for award. The PIs might then search out other funding to support their work. It becomes a problem when the PI makes other commitments that then make it challenging for them to execute on a belatedly awarded TCF project. Both of these lab TTO managers desired more proactive communication from the OTT to inform them of delays in announcements and whether some POs have yet to disburse funds when others have already done so.

3.4.3. Reviewer Comments to PIs

Most contacts considered reviewer comments to PIs to be helpful; many nonselected PIs intend to apply again. In general, lab TTO managers found the quality of the reviewer comments to be good, satisfactory, or helpful, and PIs were appreciative of the reviewer comments. Contacts noted, however, a small number of PIs were dissatisfied with the feedback received. At three labs, PIs disagreed with

some of the reviewer comments. A OTT TCF representative said that two PIs reached out to them to see if they could rebut reviewer comments.

Two interviewed PIs made unsolicited comments about how the reviewer comments were helpful and valuable. PIs said the comments were candid and the reviewers raised valuable questions. The comments also provided PIs with guidance on potential challenges that they may face and pointed to existing research and publications PIs should consider as they move forward.

Two lab TTO managers encountered a lack of explanation for why unselected proposals were not funded. They noted that most of scores and comments on the unselected proposals were positive and it was unclear to them why they were not funded. In one case, they reached out to the Program Office for an explanation and learned the Office had run out of budget. One of these lab TTO managers suggested there be more transparency in how the decision was made.

PIs from nearly all labs whose proposals were not selected for funding were planning to apply again in a subsequent round, according to lab TTO managers (9 of 10).[33] At three of those labs, the PIs were specifically going to revise their proposals based on the reviewer feedback they received. While two of those lab TTO managers reported that PIs learning from the comments and were making slight changes by "tweaking" the proposal, the third manager used stronger language that emphasizes the credibility of the reviewer comments. He said, "We're going to be resubmitting some proposals that failed last year because the feedback told them what they needed to do to have a successful proposal."

At the tenth lab, the lab's TTO representative encouraged the PI to submit again, but the PI reportedly became busy and did not submit a proposal in a subsequent round. This was the PI who reported positive comments on an unselected proposal and learned they were not selected due to PO budget limitations. The lab contact with whom we spoke suggested the feedback about "budget uncertainty" discouraged the PI from applying in a subsequent round.

Some PIs of unselected proposals built on the feedback they received to respond to other funding opportunities (6 labs).[34] At three labs, PIs revised their proposals and entered lab-level funding competitions, including one lab's technology development program and another's lab pitch competition. Another lab contact mentioned that a TCF nonselected PI applied for ARPA-E funding and won that; managers at the other two labs did not have specific examples to share.

We heard of two cases where PIs of unselected proposals were not going to change their plans based on reviewer feedback: one PI disagreed with the reviewer and the other is planning to submit the same proposal and hope for different reviewers.

[33] The representative from the 11th lab said that he did not know if any PIs were planning to submit in a subsequent round and that there may be some that he might be unaware of.

[34] Managers at four other labs said they did not know, and a contact at a fifth lab said that PIs are planning to, but have not yet built on their TCF feedback to submit to another funding opportunity.

3.5. Execution Process

Once OTT announced the selections, labs began CRADA negotiations. This section reviews findings related to CRADAs and challenges associated with them. Then, we discuss tracking and reporting requirements PIs must comply with as they execute and finish their projects.

3.5.1. CRADA Finalization

Most partnering teams experienced extended periods to finalize the CRADAs, putting the commercialization research on hold, jeopardizing partner interest, disrupting lab staff planning, and leaving PIs without an ability to charge for their time spent trying to move the project forward. Most of the labs and PIs that negotiated CRADAs reported challenges to getting them in place in the specified six-month timeline (7 of 10 labs; 7 of 9 PIs).[35] Teams with external partners cannot start work on TCF projects until CRADAs are finalized, which can be 6 to 12 months after the proposal was submitted. In one case, a PI's partner rescinded its commitment because of the time elapsed before project work could start (captured in Table 3-1).

All lab mangers said the challenges were related to general CRADA processes and were not specific to TCF. For example, contractual language related to non-disclosure agreements, advanced pay, liability, or government indemnification caused hurdles when negotiating with industry; rarely was it the statement of work. As one lab TTO manager summarized,

> *"When you negotiate an agreement with a business, it doesn't always follow a set format or timeline. And depending on what industry the company is in and their posture and all that, it can take more or less time to engage and get a deal finalized."*

Another lab TTO manager mentioned that their partners struggled to agree on terms that complied with DOE requirements and still another lab contact mentioned that obtaining approval from headquarters for their international partners lengthened the CRADA process.

At the time of the interviews, five of nine interviewed PIs had not completed their CRADA agreements, which was nearly nine months after award announcement. One interviewed partner who executed a sub-agreement instead of a CRADA said that was also a drawn-out process. Some PIs expressed concerns that these CRADA negotiations may extend beyond the six-month deadline and they may not be able to start their work.

Three interviewed PIs said the CRADA negotiation process as a whole is cumbersome and two PIs reported the CRADA requirements were too strict and rigid. PIs also noted that negotiating CRADAs with small businesses and start-up companies can be especially challenging as those types of partners are not large enough to have internal staff and legal teams to support execution of these agreements.

[35] The eleventh lab reported having all Topic 1 proposals and did not have to prepare CRADA agreements.

Most labs (7 of 10) reported using the standard, or long-form, CRADA. [36] The other three labs said that they used either the short or long form depending upon the project's total value; larger project amounts required the long CRADA form.[37] The form of CRADA used does not appear to drive challenges getting CRADAs in place because long-form users were evenly split between reporting challenges (4 contacts) and reporting no challenges (3 contacts).

An issue facing PIs is how to bill time while finalizing agreements before project work can begin. PIs reported spending a significant amount of time working with DOE in the Annual Operating Plan (AOP) process and with industry partners during CRADA negotiations. PIs cannot bill their time and would like to have some mechanism to do so during this critical first stage of the project. One PI summarized frustration with the lengthy CRADA process and waiting for the TCF award:

> *It is out of my hands now; it's in the lawyers' hands. I had a lot of people from [my lab] help me, but we sent the industry partner so many emails and they keep saying it's under review. I feel like there is nothing I can do right now, and I don't have any money [and thus cannot start work]. So, it is frustrating.*

Another PI provided their perspective on how the long CRADA timeline was at odds with TCF's goal of expediting commercialization:

> *You really need people to sign off on the CRADA paperwork as soon as it comes through. It will be two years from when we wrote the proposal to the time when we finally get started. And I know that is not what anyone wants. I mean the whole goal is to expedite commercialization.*

For another PI, the length of time their CRADA negotiations took led to staffing complications. The PI had reserved hours for other lab staff to work on his TCF project but did not expect the CRADA negotiations to take as long as they did. The staff to whom he had promised work had to wait while the agreements got finalized.

Three lab TTO managers and one PI suggested industry partners look at the CRADA terms before they commit to being a partner on the project. These managers suggested the industry partners agree to a CRADA template or to standard terms and conditions before the PI submits the proposal. As one lab TTO manager explained:

> *"That would potentially streamline the CRADA process because they'd already have seen the contract and agreed to accept it. The other thing is that it would be a proactive statement by the company that they're really interested."*

Another lab TTO manager and two PIs suggested that shortening the CRADA form itself or simplifying the DOE approval process of CRADAs would help. Half the lab TTO managers (5 of 10) could not offer suggestions to accelerate CRADA negotiations, though two of those five said that as lab staff gain

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[36] One of these seven respondents said, "My understanding is that there is no such thing as a short form. I hear about this mythical creature, but I don't think any lab has ever used one." At this link is a DOE short form CRADA: *https://www.netl.doe.gov/File%20Library/Business/tech-transfer/samples/CRADA-Model---Short-Form---2-17-15.pdf*

[37] One lab contact said that project amounts above $350,000 require the long form and another contact said the threshold is $500,000.

experience, the negotiations go more smoothly.[38] Similarly, one partner also described CRADA negotiation as a valuable experience because now both the partner and the PI understand the process, which they anticipate will make future CRADA negotiations more straightforward.

Half the labs (5 of 10) encountered situations with partners that caused them to revise CRADA work scope from what was written in the proposal, according to lab TTO managers. We present these cases in Table 3-1.

Table 3-1: Reasons for Changes in Agreements

Situation	Resolution
Partner could not fulfill cost share commitment	Significantly re-scoped statement of work
Partner could not fulfill cost share commitment	Recruited different partner
Delay in announcing selection or making award	Recruited different partner
Change in the technology application	Instead of doing a CRADA, they did a subcontract
Lab was going to purchase equipment, but partner decided to purchase it	Allocated funds differently in CRADA

Two labs mentioned changes in the agreement related to the timeline. In another case, a plant closed for the winter, necessitating the PI to revise the agreement to extend the period of performance. Another lab contact did not describe specific problems and characterized the alterations to his lab's TCF agreements as minor changes to milestones and deliverables. Finally, one more lab did not offer specifics but said that when they needed to make changes, they sought the approval of OTT and the funding PO. Three lab TTO managers reported they were unaware of any changes made to the contracts compared to the proposals.

3.5.2. Tracking and Reporting Requirements

Contacts were satisfied with tracking and reporting requirements. OTT staff chose not to impose regular TCF reporting requirements on the Program and Technology Offices, wanting them to manage their TCF projects like they do their other lab projects. As one Program Office representative explained,

> *The Program Offices have different protocols and processes of how they manage projects. There's not really a consistent TCF metric collection process or management approach. I don't know that we need a standardized or centralized process, but there are some areas where it might be good to have explicit commonalities across the Technology Offices and Program Offices for how TCF projects are managed. But that's a perennial question we asked ourselves.*

[38] The contact at the tenth lab said that CRADA negotiations go more smoothly with industry partners familiar with lab processes than with partners new to lab processes.

One Program Office contact said their project teams submit monthly spending reports and quarterly status reports. Another Program Office contact said the status and spending reports are in a joint quarterly report.

The lab TTO managers with whom we spoke were largely unfamiliar with the TCF reporting requirements; five said they did not know what the reporting requirements were. Two managers said the reporting requirements varied by funding office. Three lab TTO managers reported being aware of the final report the PI must submit at the close of the project, though they were unsure of its content, and two lab TTO managers mentioned the five-year follow-up report required of partners using the CRADA to document any commercialization successes. One PI wanted to have more communication on the report format.

The lab TTO managers were similarly unfamiliar with what metrics the project teams were required to report. Managers from three labs described some of the standard metrics they track for all projects, including TCF projects. These metrics were: project spending, project milestones, records of invention, formation of companies, and any commercial sales.

All labs use their normal budgeting and accounting processes to track TCF expenditures and matching funds. Two lab TTO managers elaborated to say that their labs' budget offices track spending by the PI and spending by the partner to ensure it progresses at an acceptable rate. At both labs, the budget office sends the PIs a monthly update on the project's financial status. Three lab TTO managers mentioned that their accounting department assigns a specific TCF charge code, so they can flag TCF projects and report on those separately if needed. One lab TTO manager said that the responsibility to track expenditures on TCF projects falls on the PIs because the PIs are the ones managing the projects.

At the time of data collection, most 2016 TCF projects had not reached completion. Seven labs reported that none of their projects had finished the defined scope of work, while three labs had one project completed. The eleventh lab had two projects completed at the time of the interview.

Of the four labs with completed projects, three lab TTO managers had not seen the end-of-project reports and could not speak to their quality. The one contact who had seen the final report said it was of high quality and he was impressed with it. The lab staff reportedly used the lab's "CRADA close out process," which he said contributed to the high quality. Managers from three labs without completed projects anticipated their PIs would use their labs' final CRADA report template when drafting the final report.

We asked the one contact who had seen the final project report to comment on how effectively it conveyed accomplishments relevant and sufficient for the lab and DOE to assess attainment of project and TCF goals. He said the final report was about 80% effective in conveying accomplishments and that some additional questions could be added to the report to assist in assessing accomplishment of program goals.

One interviewed PI was familiar with the reporting requirements and found them to be more relaxed than other DOE programs. The PI supported the reporting requirements of their managing Program Office, finding them friendly to industry partners because they did not require too much reporting from them.

3.6. Additional Considerations

This section presents lab TTO managers' suggestions for improving the TCF program from their perspectives, including areas in which they or PIs could use more support. We also present lab TTO managers' views on how well TCF complements other OTT programs and the multiple ways the TCF program benefits the labs.

3.6.1. Suggestions for Improvement

Contacts offered multiple suggestions for improvement, with a majority commenting on communication after award announcement. Lab managers' suggestions for improvement reflect findings presented in other sections (Table 3-2). Improved communication and support from the Program Offices after award announcements was the most commonly mentioned area in need of improvement (5 of 11 lab TTO managers; 3 of 9 PIs). Three lab TTO managers specifically suggested more support during CRADA negotiations, including more flexibility in the templates and showing prospective partners a CRADA template when seeking their commitment. As one of these managers explained:

> *"Project initiation stage [could be improved] and smoothing out some of the wrinkles associated with getting CRADAs in place. The time between the award and start of the period of performance would be where I think support would be the most useful."*

Three PIs also recommended that OTT provide more support to project teams during CRADA negotiations. PIs suggested that OTT create point of contact(s) for TCF where both PIs and industry partners can reach out with questions, check-in on status updates, and receive guidance on how to navigate CRADA negotiations. Furthermore, PIs said that it would be helpful to have someone at OTT who could communicate with industry partners and lab staff and nudge them to complete the agreements in a timely manner.

Table 3-2: Lab Managers' Suggests for Improvement (n=11)

Suggestion	Number of Lab Managers	Report Section with More Information
Better communication after award announcement	7	3.4.1
Copy lab TTO on communications to PIs	6	3.4.1
Consistency in solicitation timing year-to-year	4	3.2.1
Timely reviews	4	3.4.2
Reduced cost share	4	3.2.3
Bigger fund overall	3	3.2.3

Four lab TTO managers and one partner said that reducing the required cost share would be helpful. The labs have limited royalty dollars to fund their match on Topic 1 proposals, while the partner match on Topic 2 proposals is sometimes beyond the reach of small businesses or start-ups. Lab managers wanted

to see the match reduced to 20% or be a two-to-one ratio instead of one-to-one (see Section 3.2.3 for more on funding the match).[39]

Four lab TTO managers suggested that program processes would be improved if OTT could provide award decisions in a timely manner and ensure all notifications are issued at the same time, including copying the lab TTO on all electronic communication to the labs' PIs. Section 3.4.2 discusses this in more detail. Lab managers also preferred that the solicitation be issued at a consistent time each year, which would better help them prepare lab resources to support PIs as they prepare proposals and develop relationships with potential industry partners (Section 3.2.1 ends with more information on this). Finally, three lab TTO managers and one interviewed partner suggested that if the overall TCF fund was larger, more PIs, companies, and technologies could benefit from TCF participation.

All interviewed lab TTO managers said that, in general, support from the TCF program staff at OTT and the POs has been adequate (11 of 11 labs). Some lab TTO managers emphasized that OTT staff were particularly responsive during the solicitation, finding the webinars helpful (3) and the Q&A sessions valuable (2). Weak spots in program support included confusion around the cash contribution in the FY16 solicitation, and the handoff from OTT to the POs after the awards were announced.

Managers from all labs reported that the TCF processes have been fair. Two managers reflected that the delays in announcing the 2017 selections made the processes inefficient, and one lab contact thought the selection decision-making was not transparent.

Contacts from the two Technology Offices explained their limited involvement in the TCF program. They described confusion among their colleagues about the TCF program and how it relates to other commercialization-focused programs. They said that the Technology Office staff's lack of understanding about TCF results in them not promoting it during their regular interactions with lab contacts. They described this as a missed opportunity and implied that more applications could be generated if the Technology Office staff were more aware of the TCF program and its timeline, so they could encourage researchers to apply.

An ancillary benefit of the TCF program is that its review process facilitates representatives from the Program and Technology Offices to interact and learn what each other is doing. In this way, EERE has educated the other Program Offices about Energy I-Corps. Technology Office representatives described "community of practice" meetings where TCF would be discussed, which allowed them to receive updates on TCF timelines. One contact said the meetings maintained a line of communication between everyone, but since those meetings have ended, Technology Office staff have largely "been in the dark" about TCF.

[39] EPAct requires a 50% funding match for demonstration and commercialization awards. It specifies a 20% match for applied R&D, which contacts may have in mind when offering this recommendation.

3.6.2. Synergy with Other DOE OTT Programs

Most lab TTO managers (8 of 11) reported synergy between the TCF program and other DOE programs designed to promote technology transfer of lab inventions. The lab TTO managers mentioned the following programs: Energy I-Corps (6), Small Business Vouchers (SBVs; 2), Small Business Innovation Research (SBIR; 1), and Lab Bridge (1).[40]

Most of the managers who mentioned Energy I-Corps (5 of 6) viewed it as a valuable precursor to applying for TCF. The customer discovery interviews in the Energy I-Corps training, where PIs talk to industry, facilitate their relationship building with appropriate candidates for industry partners on TCF proposals. The customer discovery interviews also help the PI learn the commercialization potential of their technology's application, which they can then build into their TCF proposal.

Here is how one lab TTO manager said his lab views the complementarity of OTT programs:

> *Having these programs allows us to think about the whole commercialization pathway as a system, rather than silos of activity, because they all focus on innovation at different stages of technology maturation or skills developed on the part of PIs.*

Additionally, two interviewed PIs had participated in Energy I-Corps before TCF and similarly reported a natural progression and cohesion between the two programs. Through Energy I-Corps' customer discovery activities, one PI identified an industry partner suitable for TCF, which reportedly made the TCF proposal process more straightforward. One industry partner corroborated these findings, saying that their PI's participation in Energy-I-Corps gave the PI a better perspective on industry needs and how to appropriately engage industry.

One lab contact said that PIs at his lab do not follow a progression from Energy I-Corps to TCF, but rather that PIs who participate in either TCF or Energy I-Corps are then keen to participate in the other program. As this contact described, some PIs who received TCF funding decided they needed to learn more about commercialization and sought out Energy I-Corps training. In other cases, PIs who went through Energy I-Corps training decided TCF could help them bridge the TRL valley of death and submitted TCF proposals.

The three lab TTO managers who did not view the OTT programs as working together viewed the programs as distinct and standalone, noting there is no explicit coordination among those programs. Two of these managers mentioned how Energy I-Corps training had been limited to researchers doing EERE work and their labs' researchers worked on nuclear energy and could not participate.

[40] In the interviews, we did not ask lab TTO managers to list other programs they knew of. These programs were spontaneously mentioned in the course of answering the question: How do TCF and other OTT programs work together to promote commercialization? Had we asked directly about other programs the managers were aware of, the number of managers mentioning these programs would likely have been greater.

4. Conclusions and Recommendations

We offer the following conclusions and recommendations. The letters following the conclusion link to the key findings in the executive summary.

Baseline and Soft Impacts

Conclusion 1: The TCF program design stimulated maturation of non-roadmap technology that would not have occurred otherwise. TCF fills a key funding gap between lab-supported research and industry willingness to support lab technologies. Lab TTO managers reported that neither their labs nor the Program Offices would have been likely to fund the TCF-awarded technologies in the absence of the TCF program. (Findings A, D)

> **Recommendation:** None.

Conclusion 2: The TCF structure leads to new industry partnerships and strengthens existing industry relationships, though the turnaround time coupled with cost share leads many PIs to rely on existing relationships. The TCF Topic 2 opportunity necessitates engagement with industry to fulfil cost share requirements. However, the cost share commitment from an industry partner requires a trusting relationship, which can be challenging to develop from scratch in a few months. This has led some PIs to pursue industry partners with which they had an existing relationship. All three of our interviewed FY17 industry partners had existing working relationships with the labs. (Findings B, E, F, H)

> **Recommendation: Consider extending the time between the solicitation announcement and proposal submission and publicizing the solicitation schedule one or two years in advance, if DOE OTT seeks to increase the number of awarded projects with industry partners that have never collaborated with a national lab.**

Conclusion 3: TCF implementation has strengthened the interactions of lab TTOs and PIs, and TCF processes can further reinforce the lab TTO. Because the TCF program has a unique focus on technology transfer, the lab TTO is more involved in proposal development than with other funding opportunities. This intra-lab collaboration has heightened PI awareness of lab resources to assist with proposal development and enabled PIs to learn about the commercialization process more broadly. Nonselected PIs have also experienced these effects according to lab TTO contacts. (Findings C, G, H)

> **Recommendation: Maintain the lab TTO as the lab point of contact for TCF program and ensure communication flows through the lab TTO rather than directly to the PIs**.

Process Evaluation

Conclusion 4: DOE OTT has demonstrated continuous improvement by revising its processes. TCF program staff revised the letter of intent process, added explanations of the cash requirement and technology areas to the solicitation, and revised the independent merit reviewer recruitment process. (Findings G, I, J)

> **Recommendation: Continue collecting feedback from lab and Program Office contacts to maintain a commitment to continuous improvement.**

Conclusion 5: Predictability of the TCF solicitation is essential to participants. The annual nature of the solicitation contributes to its effects because it ensures that PI and lab thinking about commercialization and partnering occurs throughout the year. Because building industry relationships takes time and because PIs and the labs know TCF will be available again, they described cultivating industry relationships throughout the year and looking at how to position technologies under development to attract industry partners. However, inconsistent issuance of the annual solicitation weakened the ability of the labs to effectively prepare for these planning efforts. (Findings E, F, G)

> **Recommendation: Maintain consistency in the timing of the TCF solicitation year-to-year to support these ongoing, lab-based planning efforts.**

Conclusion 6: Potentially viable technologies appear to exceed submitted proposals as labs need to limit their exposure to the lab cost share requirements; and industry cost share requirement is a barrier to partnerships with small businesses. Most labs reported restricting the number of Topic 1 proposals they submit to TCF as their limited lab royalty funds would not be able to support all technologies they believed worthy of TCF consideration. Lab contacts reported challenges in engaging smaller partners. (Finding H)

> **Recommendation: Consider feasibility of a reduced cost share on Topic 1 proposals, especially select technology areas for which OTT might want to receive a greater number of proposals.**

> **Recommendation: Consider approaches to facilitate small business and start-up participation, such as coupling TCF and SBV awards.**

Conclusion 7: Improvement is needed in the award notification process and in communication from Program Offices to selected labs and PIs. The award notification process used in FY16 and FY17 caused confusion for lab PIs and TTO managers. PIs at the same lab were notified at different times and only sometimes was the lab TTO informed of award decisions. PIs and labs report uncertainty about whom to contact and to report to after awards are made. PIs also desired better communication about reporting requirements, which are set by the funding Office. (Findings L, M)

> **Recommendation: Standardize selection notification process so that announcements for all PIs occur at the same time and go first or concurrently to the lab's TTO managers.**

> **Recommendation: Establish protocols for how the Program and Technology Offices initially communicate with the selected PIs. Provide a point of contact for PIs and industry partners to contact about TCF once responsibility passes from DOE OTT.**

Conclusion 8: **CRADA negotiations between industry partners and labs can be protracted, negatively affecting PIs and partners.** Industry interest can wane in the time elapsed between proposal submission and project start dates. PIs do not have a way to bill for their work during contract negotiations. (Findings O, P)

> **Recommendation:** **Consider authorizing PIs to charge a small amount of the TCF contract award for their time spent involved in CRADA negotiations (for example, up to 2%).**
>
> **Recommendation:** **Add an appendix to the TCF solicitation that includes a representative CRADA (absent a statement of work) so that industry partners are aware of typical CRADA terms prior to committing to partner on the proposal.**
>
> **Recommendation:** **Consider advocating within DOE for continued study of CRADA negotiation challenges with the goal of identifying ways to improve the process.**

Appendix A. List of DOE National Labs

The participating and nonparticipating labs were eligible to submit Technology Commercialization Fund (TCF) proposals in Fiscal Years 2016 and 2017 (FY16 and FY17; Table A-1). The participating labs had awarded TCF projects and the nonparticipating labs had yet to submit a TCF proposal at the time of data collection. The labs and facilities indicated in the table as not in the sample frame were eligible to participate in TCF in FY17, but were not sampled as part of our research efforts for this report. To the best of our knowledge, those labs had yet to submit a TCF proposal at the time of data collection.

Table A-1: Study Participation Status of DOE National Labs and Facilities

National Lab or Facility	Role in Study
Ames Laboratory	Participating lab
Argonne National Laboratory	Participating lab
Brookhaven National Laboratory	Participating lab
Fermi National Accelerator Laboratory	Nonparticipating lab
Idaho National Laboratory	Participating lab
Kansas City Plant	Not in sample frame
Lawrence Berkeley National Laboratory	Participating lab
Lawrence Livermore National Laboratory	Participating lab
Los Alamos National Laboratory	Participating lab
National Energy Technology Laboratory	Participating lab
Pantex Plant	Not in sample frame
National Renewable Energy Laboratory	Participating lab
Oak Ridge National Laboratory	Participating lab
Pacific Northwest National Laboratory	Participating lab
Princeton Plasma Physics Laboratory	Nonparticipating lab
Sandia National Laboratories	Participating lab
Savannah River Site/Savannah River National Laboratory	Nonparticipating lab
SLAC National Accelerator Laboratory	Nonparticipating lab
Thomas Jefferson National Accelerator Facility	Nonparticipating lab
Y-12 National Security Complex	Not in sample frame

Appendix B. DOE Technology Commercialization Initiatives

DOE conducts and has conducted a number of technology commercialization initiatives in addition to the TCF, the subject of this evaluation study. This appendix identifies initiatives active in 2016, 2017, or 2018.[41] Table A-1 identifies these initiatives and characterizes the extent to which their impacts might confound an assessment of TCF impacts.

B.1. Lab Partnering Service (LPS) (2018 to Present)

LPS is an on-line, single access point platform for investors, innovators, and institutions to identify, locate, and obtain information from DOE's 17 national labs. This tool will provide industry with a more efficient way to harness technical expertise and intellectual property housed at DOE's labs.

B.2. Energy Investor Center (EIC) (2016 to Present)

DOE launched EIC in 2016 to create a single point of access for investors to access DOE resources to help unlock the potential economic benefits of the energy marketplace. EIC is a one-stop-shop for investors to connect with the world-leading energy experts at DOE labs, acquire the latest research studies, identify promising energy opportunities to fund, and develop strategic partnerships.[42]

B.3. Energy I-Corps Program (2015 to Present)

Energy I-Corps is a U.S. Department of Energy (DOE)-funded pilot intended to accelerate the commercialization of clean energy technologies from DOE national laboratories. The Office of Energy Efficiency and Renewable Energy's (EERE's) Technology-to-Market program provided $2.3 million (fiscal year 2015) to launch the Energy I-Corps pilot and received FY 2016 and FY 2017 funding to continue operations. Energy I-Corps trains selected lab scientists and engineers in techniques to accelerate technology commercialization. Training occurs in a group setting with extensive individual coaching and feedback provided by experienced entrepreneurs.

41 For more information about the history of DOE technology maturations programs see "Department of Energy Technology Maturation Programs," IDA Science and Technology Policy Institute, May 2013 available at *https://www.ida.org/idamedia/Corporate/Files/Publications/STPIPubs/ida-p-5013.ashx*.

42 *https://www.energy.gov/technologytransitions/services/us-department-energys-energy-investor-center*

B.4. Lab-Embedded Entrepreneurship Programs (LEEP) (2014 to Present)

Lab-Embedded Entrepreneurship Program (LEEP) enables collaboration between a lab and one or more partners outside the Federal government (usually from industry, nonprofit organizations, or academia, domestic or foreign) to collaborate and share the results of a jointly conducted research and development project. The lab and participant may share costs or the participant pays full cost. DOE estimates the typical period of collaboration to span one month.[43]

LEEP is funded by EERE's Advanced Manufacturing Office, and co-managed with EERE's Technology-to-Market Program. LEEP takes top entrepreneurial scientists and engineers and embeds them within the DOE national laboratories to perform applied research and development (R&D) with the express goal of launching a clean energy business. In addition to providing technological access and support, LEEP trains innovators to develop entrepreneurial acumen and skills while introducing them to ecosystem partners to facilitate commercial and investment opportunities. This dual focus on R&D and entrepreneurial development provides innovators with a platform to take their ideas from the lab onto the commercialization pathway.

LEEP currently comprises three programs: Cyclotron Road at Lawrence Berkeley National Laboratory, Chain Reaction Innovations at Argonne National Laboratory, and Innovation Crossroads at Oak Ridge National Laboratory.

B.5. Energy Innovation Portal (2010 to Present)

The Energy Innovation Portal is a one-stop resource for organizations to find and license technologies developed with EERE funding and available for licensing from national laboratories and participating research institutions. Developed and managed by the National Renewable Energy Laboratory (NREL), the Portal was created to simplify access and increase private sector licensing of energy efficiency and renewable energy technologies at DOE laboratories. The Portal contains over 23,000 DOE-created patents and patent applications, providing streamlined searching and browsing of patents, patent applications, and marketing summaries for clean energy technologies. The Portal also allows interested parties to directly contact the licensing representative from each lab and improves opportunities for "cross-laboratory" intellectual property bundling.

B.6. Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) (1983 to Present)

Both the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs award funds for innovation research through highly competitive solicitations. Both encourage domestic small businesses to engage in research and development for innovations with the potential for commercialization. With an SBIR award, the PI must have primary employment with the small business concern (SBC). SBIR awardees may partner with a research institution (up to 40% of the award amount).

[43] *https://www.energy.gov/eere/wind/how-partner-national-labs*

STTR awardees must partner with a research institution (up to 60% of the award). STRR's role is to bridge the gap between the performance of basic science and commercialization of resulting innovations.

DOE is one of eleven federal agencies (in 2017) federal agencies that participates in SBIR and one of five agencies (2017) that participates in STTR. Federal statute sets the mandatory participation requirements based on agencies' annual R&D budgets.

B.7. Small Business Voucher Pilot (SBV) (2015 to 2017)

EERE's Small Business Vouchers (SBV) pilot connected clean energy small businesses with the world-class resources at the U.S. Department of Energy's national laboratories. Through 2016, EERE was providing up to $20 million in vouchers so that small businesses could request technical assistance from national laboratories to help bring the next generation of clean technologies to market. Through the SBV pilot, eligible small businesses could tap into the reserve of national laboratory intellectual and technical assets to overcome critical technology and commercialization challenges, including: prototyping, materials characterization, high performance computations, modeling and simulations, intermediate scaling to generate samples for potential customers, validation of technology performance, and designing new ways to satisfy regulatory compliance. Eligible small businesses could request a voucher for use at a national laboratory valued between $50,000 and $300,000.

B.8. Agreement for Commercializing Technology (ACT) (2011 to 2017)

ACT enabled labs to partner with non-federal entities to complete a project using highly specialized or unique DOE facilities, services, or technical expertise. The participant pays full cost recovery plus an additional negotiated compensation to the lab. DOE estimates the typical period of collaboration to span one month.[44] Through ACT, the labs could negotiate and enter agreements directly with the private sector sponsors using terms and conditions that are more consistent with industry practices. Some of the benefits that the labs offered under an ACT included waiver of Advanced Payment requirements, fixed price contracting, performance guarantees, IP flexibility, and the option for a government research license for subjects' inventions instead of the broader a government use license.

[44] *https://www.energy.gov/eere/wind/how-partner-national-labs*

Appendix C. TCF Program Logic

C.1. Why and How Logic Models Are Used

Accepted best practice in planning an evaluation of program processes and outcomes is to begin with a clear description of the purpose and audience of the evaluation and a clear description of the program to be evaluated. The logic model is a management and evaluation tool that describes the goals of the program and the strategies designed to achieve these given the context in which the program operates. A logic model includes inputs, activities, and outputs produced with partners, the sequence of outcomes that follow, the major influences on success or failure, and the linkages among these elements. Once the program logic (also referred to as theory of change) is clear, the most important areas to measure are clear, as are the questions the evaluation must investigate. The process of developing a logic model is iterative as existing literature and people's knowledge are tapped. The logic shows hypotheses to be tested and will change as implementation adds information and circumstances change over time.

Logic models were developed by the evaluators from TCF documents, interviews with TCF staff, and review of literature on evaluation of similar programs. Based on feedback on a draft of this evaluation plan, the logic model will be modified. One purpose of a logic model is to communicate succinctly the basic goals and strategies to people not familiar with the pilot study. We have done that in a simple one-page model that is shown in Figure D-1. We use Figure D-1 as a guide for describing the logic of how TCF will achieve its goals. The logic flow in the figure is left to right, and within the columns, top to bottom.

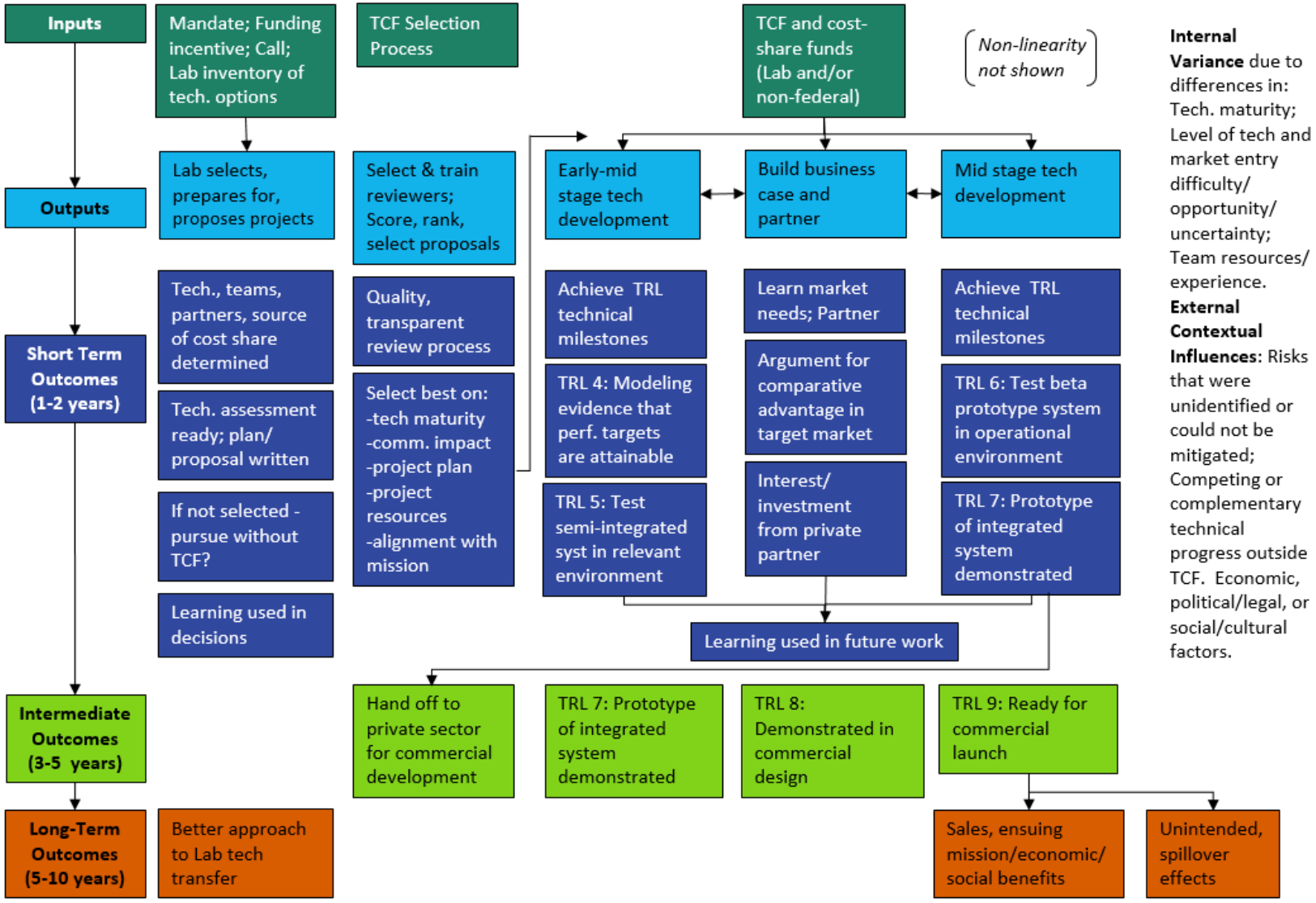
C.2. TCF End Goals and Rationale

The TCF is part of a broad array activities that DOE and its facilities (Laboratories, facilities, sites) undertake to ensure Federal research and development (R&D) investments in technology with commercial potential find their way to a viable market. What sets TCF apart from other DOE activities to increase the transfer of Lab-developed technologies to industry and commercialization is two-fold: (1) providing funds for what is known as the "valley of death" in the R&D continuum, and (2) competitive selection of R&D efforts that are focused on specific commercial applications and already have, or soon will have, private sector partners co-developing the technology.

The DOE facilities are proven partners in collaborative research and development projects that provide the foundational science and technology for the private sector's development of new products and processes in many industries. Today there are thousands of patents, licenses and cooperative R&D between the DOE facilities and private partners. Yet there is a reservoir of intellectual property that has not transitioned to the private sector, because the technology may not be mature enough to attract a partner or its market potential may not be fully understood.

DOE's facilities have consistently identified as a problem the lack of funding to develop technologies to a stage that attracts private sector investment (though interest may be there). In many cases public funding from DOE and other sources supports R&D activities up to an early Technology Readiness Level (TRL) but is cut off before the technology is tested and prototypes validated in an application to a degree that a private sector partner would see the balance of risk and potential benefit warranted investment in further development and testing via a license or Cooperative Research and Development Agreement (CRADA). This was also a conclusion of a 2013 White House Office of Science and Technology Policy study.

Figure D-1: DOE Technology Commercialization Fund Logic Model



Two other conclusions of the 2013 study are addressed by TCF. One is that National Laboratories are not very visible and accessible to industry, and that certain regulations make it difficult for National Laboratories and industry to interact. The second is that the centralization/decentralization of technology transfer functions at the agency and Laboratory levels affects the speed of implementation of technology transfer actions, the consistency of policies across Laboratories within an agency, and the ability to share best practices.

The TCF anticipate that their approach will have three primary benefits that will lead to achievement of the two program goals:

1. Creating a stronger incentive for National Laboratories to identify their most promising technologies and industry partners for commercialization;
2. Empowering a broader set of potential industry partners to engage with the National Laboratories; and
3. Enabling the Program Offices to identify Laboratory technologies and industry applications with high potential for commercial impact aligned with the Program Office's mission.

C.3. Program Stakeholders

DOE Program Offices. The TCF Program fills a mandate and offers a structured way of pursuing technology maturation of R&D supported in the past which has potential application commercially that is aligned with mission, but not on their programmatic roadmap.

Federal Laboratory Management and Staff. Laboratories have financial incentives to participate and see potential for further investment and benefits to reputation if successful. Researchers are offered the opportunity to pursue R&D of technical interest to them, as well as the potential psychic reward of utilization and making a difference.

Private Sector Partners. Companies who are more or less familiar with the opportunities of working with the Federal Laboratories may be approached by the Labs about potential collaboration in areas attractive for their business. The 50-50 cost share arrangement reduces the risk of coordinated R&D on early or mid-stage technology prototypes.

Taxpayers. The taxpayers would see the benefits from commercialized products supported by TCF, as well as benefits of public funds spent on competitively selected, focused R&D and technology transfer.

C.4. Inputs/Resources

Inputs and resources to the TCF Program activities include the following:

- Mandates and other incentives to increase transfer and commercialization of DOE Lab-developed technologies.
- Resources of the DOE Program Offices, including Office of Technology Transition (OTT), which include technical and market expertise in management and staff and the reviewers chosen for

proposal review, program design and operation of project review and selection, and funds and oversight management provided.

- Resources of the Federal Laboratories which include technical and market expertise in management, researchers and tech transfer offices, commercialization policies and experience, an inventory of technology options, existing relationships with private sector partners and intermediaries, and matching Lab funds in some cases.

- Non-federal/private sector partner resources in cost-shared coordinated R&D, and after handing off from the Lab, which includes technical and market expertise and experience, relevant existing supply chains and customer base, and cost-shared funds.

C.5. Program and DOE Facility Activities and Outputs

Activities are organized into six groups in this logic model, as described here. Five activities are in the second row of the logic diagram, in rough sequential order reading from left to right. The Laboratories propose, then TCF reviews and selects projects. Topic 1 projects typically do earlier stage research and Topic 2 projects typically work in the middle range of TRLs. Both types of projects develop, check, and modify a value proposition and business plan as the R&D progresses. Technology maturation and commercialization are NOT a linear process but are shown in the Figure D-1, that way for simplicity of exposition. The sixth activity is shown in the row of Intermediate Outcomes because it occurs once the development and commercialization rest entirely with the tech transfer partner.

Federal Laboratory prepares and submits proposal for a TCF call. The TCF call has features that require a great deal of preparation beyond an individual Principal Investigator's participation. The requirement for 50 percent cost share by a non-federal entity means that promise of those funds must be obtained from either Lab sources for Topic 1 or partners for Topic 2. Discretionary funds within the Laboratory are scarce and would be competed for. They most likely come from license royalties. The process of finding and obtaining agreement for coordinated R&D with a partner is often a lengthy one. Existing CRADAs are not eligible. The proposals require that a technology assessment have been completed, a business case be developed, a detailed project plan written, and commitments obtained from the necessary project resources.

TCF selects reviewers, reviews, ranks, and selects projects. Brief Letters of Intent from those intending to propose provide TCF staff with guidance on areas of expertise needed in reviewers so these can be invited ready to review proposals once submitted. A minimum of two technical subject external experts and one commercial expert review and score each process. The relevant technology office then can add comments on those reviews and the proposal. Proposals are ranked within technology areas, and a merit review committee made up of representatives of each Technology Office meets to look at the highest ranked proposals. The chair of that committee makes the final decisions.

The funds are distributed by each Technology Office and that office manages the projects.

Research in early stage development. This activity is primarily technology maturation, Topic 1 projects, before coordinated R&D with a private sector partner. The R&D activities to reach the points in development described in TRLs 3 and 4 are included in this group. TCF requires that the technology be at least a TRL 3, so activities will have a minimum floor of working within TRL 4, moving on to activities

relevant to TRL 5. There may be exceptions to our assumptions about the TRLs and private sector partners, and as more as learned we can modify the logic as needed.

It is important to note that movement among TRLs is not necessarily linear. New technical or market-related findings can require a backward movement on the TRL ladder. Examples are a technical dead-end reached or new fundamental technical challenge found, or, since TRLs are for a specific application, if there is a pivot to a different application.

Build the Business Case and Partner. This activity sits between the early and mid-stage technology development because it occurs in both, building on what was completed during the proposal preparation phase. Building this business (or market) case is not part of the TRL description, but it is commonly understood that technology development proceeds in stages and at each major decision point about proceeding with development, there are questions about the technical case, the business case, and costs.

Key drivers of a business plan include (from the Business Model Canvas[45])

4. **Customer Segments**: Who are the customers? What do they think, see, feel, and do?
5. **Value Propositions**: What's compelling about the proposition? Why do customers buy, use?
6. **Channels**: How are these propositions promoted, sold, and delivered? Why? Is it working?
7. **Customer Relationships**: How do you interact with the customer through their 'journey'?
8. **Revenue Streams**: How does the business earn revenue from the value propositions?
9. **Key Activities**: What *uniquely* strategic things does the business do to deliver its proposition?
10. **Key Resources**: What unique strategic assets must the business have to compete?
11. **Key Partnerships**: What can the company *not* do so it can focus on its key activities?
12. **Cost Structure**: What are the business' major cost drivers? How are they linked to revenue?

Stage Gate criteria combine technical and business aspects and suggest compiling information and expert opinion on the following characteristics, which the framework groups into criteria that must be met for additional investment in technology development, and criteria that should be met.[46] These latter criteria are scored to provide a relative ranking of an organization's opportunities.

Must meet criteria:

- Strategic alignment with business unit's strategy,
- Reasonable likelihood of technical feasibility,
- Meets environmental,

[45] A Business Model Canvas is a framework used in lean startup practices; the business model canvass is a summarized business model that lets one look at nine building blocks of a business on one page. Essentially, this is a diagram of how a company creates value for itself and its customers.

[46] Stage-Gate International, Optimizing the Stage-Gate Process: What the Best Companies are Doing (Part Two), 2002.

- Health and safety and legal policies,
- Positive return vs. risk, and
- No showstoppers.

Should meet criteria include (scored on a scale of 1 to 10):

- Strategic fit and importance,
- Product advantage (unique benefits, meets customer needs better, value for money),
- Market attractiveness (size, growth; competitive situation),
- Synergies (marketing, technological, manufacturing),
- Technical feasibility (technical gap, complexity, technical uncertainty),
- Risk vs. Return (expected profitability, return, payback period, certainty of return) and
- Low cost and fast to do.

Research in mid-and later- stage development. This activity is primarily technology development, coordinated with a non-federal partner, usually from the private sector. The R&D activities to reach the points in development described in TRLs 6 and 7 are included in this group. There may be exceptions to our assumptions about the TRLs and private sector partners, and as more as learned we can modify the logic as needed. In any case, moving through development, testing and validation of prototypes nearer to commercialization scale and operating environment are on the path toward commercialization.

Hand off to partner for commercial development. At some point in technology development, a decision will be made that the non-federal partner will continue on the commercialization pathway alone. We are assuming that this will be at the stage where integrated pilot systems are being demonstrated in a near operational environment, or TRL 7, but it can vary. Activities would be untaken to move through TRLs to commercial launch (TRL 9).

C.6. Anticipated Program Outcomes

4.1.1. Short Term Outcomes (1-2 years) and Intermediate-Term Outcomes (3-5 Years)

For Laboratories. Even those researchers with proposals not funded learned something from the preparation process. They may have formed new relationships within the Lab and with potential private sector partners. They likely at least improved their understanding and plans for technology maturation and development, and review comments will add to this. There is a possibility that some projects may proceed with either Lab or private sector funding even if they are not selected for TCF funding. The lessons learned by non-awarded researchers may influence decisions, policy, and practice, as well as attitudes toward commercialization of Lab-developed technologies. Lessons learned can lead to modification of their technology transfer strategy and processes, improving likelihood of successful technology transfer in the future.

For the TCF Selection Process. At the end of the selection process the TCF program has as portfolio of technology maturation and development projects. The selection process itself, as well as technology office involvement and oversight of projects in the area and exchanges in the regular working group meetings, will result in lessons learned and modifications to the program design and implementation as deemed necessary.

For the Technology and Business Case Development. Meeting stated technical milestones to achieve and move through the TRLs are short and intermediate term outcomes, depending on where the technology was at the outset and the level of difficulty. Interest and level of investment by private sector partners is expected to increase as the technology moves closer to demonstration of commercial viability. The characteristics of performance and cost that are needed to secure customers are likely to improve, as well as be demonstrated in credible ways. Because there is always some uncertainty in R&D, there may be known technical challenges that cannot be met, and new challenges uncovered. Ideas about the best target customer use and segment may shift as research proceeds. There may be unintended use of the knowledge gained or technology developed, or spillovers into unexpected areas. In all cases, what the researchers learn about the technical challenges and market needs may be useful in their future work.

4.1.2. Long Term Outcomes (5-10 Years)

The end goals of the program have been described earlier. The TCF is designed to increase the number of technologies transferred from DOE Laboratories in order to contribute to mission goals and provide other economic and social benefits. There may be "spill over" in other unintended areas. In the process of implementing and learning lessons from the TCF program, DOE headquarters and Laboratories will improve their approaches to technology transfer.

4.1.3. Internal and External Influences on TCF Success

There are influences both internal and external to the TCF Program that may drive or constrain success of the program overall, and for individual TCF-funded projects.

Internal to the program, the primary sources of variation influencing success include variations among the research teams and technology involved:

- Initial stage of the technology, from idea to minor adjustment in an existing product to R&D on a possible new product,
- Level of technical and market entry difficulty and uncertainty,
- Experience in commercialization,
- Market potential (size of potential demand, extent to which market delivery infrastructure exists, etc., and
- Amount of non-TCF financial support available.

External to the program are influences that are generally beyond program control or influence, such as:

- Political visibility,

- DOE business infrastructure,
- Market needs/ opportunities,
- R&D and deployment progress outside DOE and Labs,
- Competing and supporting technologies,
- Government policies and incentives,
- Economics including energy prices, price of what the new product would replace, availability of skilled labor, etc., and
- Social/cultural norms such as consumer preferences, time horizon, etc.

Appendix D. Interview Guides

D.1. Baseline and Soft Impact

D.1.1. Office of Technology Transitions Staff

Introduction

Thanks for taking the time to talk with me today. As I mentioned in the email, the purpose of this conversation is to see how TCF processes compare to business as usual for the Program Offices and to learn whether their involvement in TCF has inspired any changes elsewhere in their work. Do you have any questions for me before we get started?

I'll be taking notes as we talk. Would you mind if I also record our conversation? The recording is just to help with my note taking. We won't share the recording or our notes with anyone unless we're legally required to do so, and we don't report anything in a way that would identify any individual respondent.

TCF before the "program" and counterfactual

Q1. Prior to the current program, how did the Program Offices or DOE management determine they were meeting the Energy Policy Act's mandate?

1. [If unclear] When did this accounting or tallying occur in the fiscal year?
2. [If unclear] How did they identify specific projects as meeting EPAct's requirements?
3. [If unclear] Who made the determination?

Q2. What documentation did DOE provide Congress to demonstrate it met the mandate?

1. Did Congress ever question the documentation?

Q3. To what extent are the Program Offices funding projects under TCF that they wouldn't otherwise typically fund? If it's relevant, we could discuss Topic 1 and Topic 2 projects separately.

1. Is TCF leading them to fund technologies that are at a different stage in the commercialization spectrum?
2. Do the Program Office's TCF-funded projects involve increased partnering with the private sector compared to projects they typically fund?
3. Has the perspective embodied in the commercialization review led the offices to fund projects they would not normally fund?

Q4. To what extent do you think TCF is giving the labs more autonomy in selecting the technologies they propose for DOE funding compared to the way DOE normally distributes project funding?

Q5. Are there other ways in which the TCF awards differed from the projects the Program and Technology Offices typically fund?

Q6. I understand that, over the decades, Congress gives DOE different directions on how much DOE and the Program Office should be focusing on market readiness and commercialization. In your time at OTT, have you noticed anything like this – the changing policy direction from Congress?

1. How well do you think the TCF program is aligning with what the current Congress wants from DOE and the Program Offices?

Participation Effects

Now I'd like to explore aspects related to decision making.

Q7. Have you seen anything to indicate that TCF involvement changed the decision criteria Program Offices use to allocate project funding?

1. [If yes] What have you noticed?

Q8. Have you noticed anything that indicates TCF involvement has changed the Program Office managers' thinking about their Office's "roadmaps" and where they put their resources?

1. [If yes] What is that?
2. [If unclear] How has TCF affected this?

Q9. Over the last few years, do you think the Program Office's perspectives on what constitutes a "promising technology" has changed at all?

1. [If yes] how? (Probe for changed perspectives on technology advancement and commercial applications.)

Q10. From their involvement in TCF, do you have a sense of whether the managers in the Program and Technology Offices learned things that lead them to think about their portfolio of technologies differently?

1. If yes, what did they learn that affected how they view their portfolio?

Q11. Since the TCF program launched in 2016, to what extent, if any, do you think the research managers in the Program Offices have developed an increased understanding of commercialization activities? Why do you say that?

Q12. Since the TCF program launched in 2016, to what extent do you think the Program Office's interest in technology commercialization increased? Why do you say that?

Q13. Can you think of any other areas where the TCF solicitation may have had an influence on the Program Offices' perspective or activities? If yes: Please describe that for me.

Closing

Q14. That's all the questions I prepared. Is there anything you'd like to add to help me better understand how the Program and Technology Offices approach funding technologies or the influence of the current TCF program?

D.1.2. Program Office Staff

Introduction

Thanks for taking the time to talk with me today. As I mentioned in the email, the purpose of this conversation is to see how TCF processes compare to business as usual for the Program Offices and to learn whether your involvement in TCF has inspired any changes elsewhere in your work. Do you have any questions for me before we get started?

I'll be taking notes as we talk. Would you mind if I also record our conversation? The recording is just to help with my note taking. We won't share the recording or our notes with anyone unless we're legally required to do so, and we don't report anything in a way that would identify any individual respondent.

TCF before the "program" and counterfactual

As you probably know, the Technology Commercialization Fund was created in 2005 via the Energy Policy Act, but the program as it is now began in 2016. The Energy Policy Act had a mandate to support projects with matching private finds to promote promising energy technologies for commercial purposes.

Q1. Prior to the current program, how did your Program Office determine that it was meeting the Energy Policy Act's mandate?

1. [If unclear] When did this accounting or tallying occur in the fiscal year?
2. [If unclear] How did you identify specific projects as meeting EPAct's requirements?
3. [If unclear] Who made the determination?

Q2. What documentation did your Program Office assemble in support of its determination?

1. What parties received this information?
2. Did these parties ever question your tallies?

Q3. To what extent is your office funding projects under TCF that it wouldn't otherwise typically fund? If it's relevant, we could discuss Topic 1 and Topic 2 projects separately.

1. Is TCF leading you to fund technologies that are at a different stage in the commercialization spectrum?
2. Do your office's TCF-funded projects involve increased partnering with the private sector compared to projects you typically fund?
3. Has the perspective embodied in the commercialization review led to your office funding projects your office would not normal funds?

Q4. Are there other ways in which the TCF awards differed from the projects your office typically funds?

1. Some contacts we've interviewed have suggested that the TCF gives the labs more autonomy regarding what projects to pursue than is true otherwise. What do you think of that assertion?

Q5. I understand that, over the decades, Congress gives DOE different directions on how much DOE and the Program Office should be focusing on market readiness and commercialization. In your time at the Program Office, have you noticed anything like this – the changing policy direction from Congress?

1. How well do you think the TCF program is aligning with what the current Congress wants from DOE and the Program Offices?

Participation Effects

Now I'd like to explore aspects related to decision making.

Q6. Over the last few years, has the decision criteria your Program Office uses to allocate project funding changed at all?

1. If yes, how?
2. What influence did TCF have on this, if any?

Q7. Over the last few years, has your thinking changed at all about your Program Office's "roadmap" and where you put your resources?

1. [If yes] How has TCF affected this?

Q8. From your involvement in the TCF program as it is now, has your thinking changed at all about what constitutes a "promising technology?"

1. If yes, how? (Probe for changed perspectives on technology advancement and commercial applications.)

Q9. From your involvement in TCF, have you learned things that lead you to think about your portfolio of technologies differently?

1. If yes, what did you learn that affected how you view your portfolio?

Q10. Since the TCF program, to what extent, if any, do you think the research managers in your Program Office have developed an increased understanding of commercialization activities? Why do you say that?

Q11. [Optional:] Since the TCF program launched in 2016, to what extent has your Program Office's interest in technology commercialization increased? Why do you say that?

Q12. Compared to your Office's other activities, to what extent, if at all, has your involvement in TCF led to increased interactions between your Program Office and the labs' technology transfer offices? Why do you say that?

Q13. Can you think of any other areas where the TCF solicitation may have had an influence on your Program Office's perspective or activities? If yes: Please describe that for me.

Closing

Q14. That's all the questions I prepared. Is there anything you'd like to add to help me better understand your Program Office's approach to funding technologies or the influence of the current TCF program?

D.1.3. National Lab Staff (Lab Manager Interview Guide)

Introduction

Thanks for taking the time to talk with me today. As my colleague Adam said in the email, we are gathering information about how labs approach commercialization and the TCF funding opportunity to help DOE measure what the program has accomplished. Do you have any questions about our work, before we get started?

I'll be taking notes as we talk. Would you mind if I also record our conversation? The recording is just to help with my note taking. We won't share the recording or our notes with anyone unless we're legally required to do so, and we don't report anything in a way that would identify any individual respondent.

Background

First, I'd like to know a little about you.

Q1. Could you tell me your title, the department or group you are in, and where that group fits with respect to your lab's technology transfer activities? Response

Q2. [If participant:] What has been your involvement in and responsibilities for your lab's participation in TCF? [If nonparticipant:] What has been you and your lab's involvement in TCF, if any?

Q3. [If participant:] Are others in your group or the technology transfer area involved in TCF? And if so, what are their titles and roles or responsibilities?

TCF Funding and Co-investment (50% Match)

I'd like now to explore how the TCF funding availability compares with business-as-usual for both the lab scientists and your group.

Q4. What funding sources are available to researchers to advance their technologies along the commercialization continuum, through the so-called valley of death, commonly considered to be TRL 4 and 5. [Probe to ensure all types of entities considered – DOE, lab, partners, anyone else.]

Q5. I'd like to know a bit about each source. Can you tell me the amount of funding typically awarded to a given researcher [range is okay]; typical number of researchers awarded funding annual; and about what percentage of applicants are typically funded.?

Q6. To what extent does your lab – perhaps your group – identify technologies to go after these funding opportunities, and to what extent is it left up to the researchers to self-identify and pursue?

1. [IF LAB DOES IDENTIFY:] How does the lab identify these technologies? Perhaps you track project TRL levels, or have regular meetings with research managers.
2. What influence, if any, has TCF had on this? [If needed, probe to understand what changed and how, and why TCF elicited this change]

Q7. How does TCF compare to the other funding opportunities? (Probe for specifics on TCF elements including the TCF proposal criteria, merit review, and Topic 2 partner match).

Q8. Are PIs more likely to submit TCF proposals than proposals to the other funding opportunity? Why do you say that?

Q9. Have you ever decided to limit the number of proposals your lab submits to any funding opportunity? [If yes] Why? How do you decide which ones to submit?

1. [IF UNCLEAR:] Who at the lab is involved in the decision?
2. What influence, if any, has TCF had on this? [If needed, probe to understand what changed and how, and why TCF elicited this change]

Q10. When the funding opportunity requires lab matching funds, do you assess the expected return on investment for the lab match? [If yes:] Please briefly describe how you assess this.

1. What influence, if any, has TCF had on this? [If needed, probe to understand what changed and how, and why TCF elicited this change]

Q11. [If participant:] For TCF specifically, are there any differences between Topic 1 and Topic 2 proposals in how the lab makes the decision to pursue the funding?

Q12. [If participant:] Has your lab gone on to fund proposed scopes not selected by TCF? [If yes:] Did something about participating in the TCF solicitation lead to your lab's decision to fund the work itself?

Q13. [If participant:] In the absence of TCF, what is the likelihood that your lab would have self-funded the proposed research?

Q14. [If participant:] In the absence of TCF, what is the likelihood that a DOE program or technology office would have funded the technologies in the absence of TCF?

Proposals

Let's explore the extent to which the TCF opportunity might influence your lab and PIs' thinking about advancing a technology. First, I am going to ask you 5-point scale rating questions, where 1 signifies "not at all" and 5 signifies "a lot." The scale is just a quick way for us to drop into a more nuanced discussion of issues. Ready?

Q15. Compared to other funding opportunities, how much does the TCF solicitation stimulate your lab and PIs to think differently about technology advancement? Would you say 1 "not at all," 5 "a lot" or some rating in between?

Q16. Compared to other funding opportunities, how much does the TCF solicitation motivate your lab and PIs to engage in business planning or commercial impact assessment? [1 – 5]

Q17. [If participant:] Compared to other funding opportunities, how much do your lab's submitted TCF proposals involve increased collaboration within the lab, such as among researchers, or between researchers and your group or other technology transfer support? [1 – 5]

Q18. [If participant:] Compared to other funding opportunities, how much do your lab's submitted TCF proposals reflect increased partnering between the lab and non-lab or private-sector entities? [1 – 5]

Now let's follow up on the items you rated a 3 or higher. Please explain your rationale for your rating TCF's influence as high in____.

[ASK AS RELEVANT:]

Q19. Stimulate different thinking about technology advancement

Q20. Engage in business planning or commercial impact assessment

Q21. Increase within lab partnering

Q22. Increase external partnering

[ASK ALL THAT GAVE ANY "1" OR "2" RATINGS]

Q23. There may not be much to say about the items you rated 1 or 2, but I want to give you a chance to elaborate on those items. Would you like to?

Q24. Can you think of any other areas that the TCF solicitation may have had an influence on project teams or lab activity compared with other funding opportunities? [Describe]

Participation Effects

Q25. To what extent, if at all, has TCF availability influenced has your lab's interest in commercialization activities increased? [Describe]

Q26. To what extent, if at all, has TCF availability influenced your lab's technology transfer strategies or approaches to other technologies under development? [Describe]

Q27. To what extent, if at all, has TCF availability influenced your PI's interest in commercialization activities?

Q28. [If participating lab] To what extent, if at all, has TCF participation influenced PIs knowledge, perspectives, or skills transferable to other technologies under development? [Describe]

Q29. [If participating lab] To what extent, if at all, has TCF participation influenced lab or PI learning that might improve likelihood of future successful technology transfer? [Describe]

Q30. That's all the questions I prepared. Is there anything you'd like to add to help me better understand your lab's approach to advancing the commercialization of technologies and the influence of TCF?

D.2. Process Evaluation

D.2.1. DOE Managers

Introduction

Thank you for making the time to talk with me today. As I mentioned, my firm is working with the Department of Energy to assess the Technology Commercialization Fund or TCF. Your feedback is valuable to help us understand its processes and how well those processes are working for the [DOE offices] Labs and project teams. There are four main sections addressing proposal solicitation, review, selection, and execution. Our interview will take about an hour. I'll be taking notes as we talk, but I'd like to record this conversation to ensure the accuracy of my notes. Is that okay with you?

Any questions for me before we get started?

Background

Q1. First, I'd like to know a little bit about you. What is your title at [DOE or Lab]? What is your role with TCF?

Q2. [If at Lab] Who else at your Lab is closely involved with the TCF program and would be good for us to speak with?

Solicitation requirements and process [ASK ALL]

This set of questions are about the solicitation for proposals and funding. Please include in your answers any differences between the 2016 and 2017 solicitations.

Q3. [Ask Don:] About how much advanced notice was given to the labs informing them of when the solicitation will be issued (2016 and 2017)? Do you anticipate any change going forward?

1. [ASK ALL:] In your opinion, does the timing of the advance notice and the deadline provided by the solicitation give the Labs and project teams enough time to get prepared, obtain partners, and write the proposal?

Q4. What are the most common questions [If DOE:] Labs and project teams have [If Labs] your staff and teams have after reading the proposal guidance?

1. [If unclear] What about the matching funds requirements, is that clear?
2. How common is it for potential proposers to have questions about qualifying partners? [Optional elaboration:] Existing CRADAs are not eligible under this process.

Q5. Let's talk more about partners. What approaches do [If DOE:] Labs and project teams take [If Labs] your staff and teams take to find interested partners? [Probe to get elaborated answer. Perhaps ask if varies by technologies, existing relationships, PIs…]

1. [ASK THE LABS THE FOLLOWING QUESTIONS]
2. Did you have any Topic 1 proposals that included partners – nonfinancial partners?
3. [If Yes:] What was your thinking in including them?
4. Were there any differences between Topic 1 and Topic 2 proposals in how you identified or involved partners?

[ASK DON THE FOLLOWING QUESTIONS]

5. About half of the 2016 Topic 1 proposals indicated partners – nonfinancial partners. Were you expecting this?
6. What was your response? Did the inclusion of partners on Topic 1 strengthen proposals?
7. There are no CRADAs for Topic 1 projects. Were there any issues regarding who would own the IP for these projects?

Q6. [If Labs:] Who is typically involved in mounting the TCF proposals – just the PIs and their teams, or does your office also get involved? [Probe to understand the distinct roles]

1. [If unclear:] What support is provided by TTO? Does TTO read the draft and advise?

Q7. Thinking about funding now... What source of non-federal funds [If DOE:] do the Labs use [If Labs] does your Lab use to fund their match for Topic 1 projects?

1. What challenges [If DOE:] do the Labs face [If Labs] does your Lab face in coming up with the matching funds?
2. [Lab] What is the process of deciding how labs fund the match (e.g., is it competitive), and who decides?

Q8. In your opinion, are the topic funding amounts appropriate given TCF's objectives as you understand them?

1. [If no] Why do you say that?

Q9. Would you say the TCF proposal submittal process is more or less difficult than other funding opportunities for technology development projects? Why do you say that?

Q10. [Lab] Were there any problems with sharing proprietary data in the proposals?

Q11. How appropriate do you think the solicitation requirements regarding commercial viability and approach to commercialization are given TCF's objectives?

1. [If DOE:] To what extent are the proposals typically providing information useful to you in assessing commercial viability? To clarify, we are not asking about typical viability of the technologies, but the quality of the information in the proposals regarding viability.
2. [If Labs:] To what extent are your PIs typically providing information in the draft proposal that you think adequately addresses DOE's need to assess commercial viability? To clarify, we are not asking about typical viability of the technologies, but the quality of the information in the draft proposals regarding viability.

3. [If Labs, if not clear:] Is this something your staff typically needs to help PIs with?
4. [ASK ALL:] Might it be appropriate for proposal requirements to include description of completed customer discovery to clarify commercial viability?
5. [ASK ALL:] And might it be appropriate for proposal requirements to specify that the proposed work scope include additional customer discovery?

Q12. This concludes my questions on the solicitations. Were there any differences between 2016 and 2017 that we didn't discuss?

Q13. Anything else you would like to add about the solicitations?

Review Process for DOE [ASK DOE]

[If DOE, else skip to next section:] Let's move on to talk about the proposal review process. In all of your answers, please discuss any differences between 2016 and 2017.

Q14. First, let me ask directly about differences between 2016 and 2017. What, if any, lessons learned from 2016 resulted in changes in the review process for 2017?

Q15. PIs/Labs submitted a letter of intent so that the TCF group can identify appropriate reviewers. How helpful or useful was that letter of intent process? (If needed, helpful in having a sense of which projects/technologies were applying for funds, helpful in getting appropriate reviewers.)

Q16. How readily was the TCF program able to identify and recruit reviewers?

1. Was the TCF program able to recruit an appropriate number of reviewers?
2. In your opinion, did the technical reviewers have the relevant technical subject matter expertise?
3. In your opinion, did the market reviewers have the relevant market subject matter expertise?
4. Did any reviewers drop out of the process?

Q17. What type of guidance and training, if any, did the TCF provide to reviewers?

1. To what extent do you think the training was effective in meeting the program needs?

Q18. Were the reviewers able to deliver their reviews by the deadlines given to them?

1. [If unclear] Did the review process get delayed? Or did it conclude in a timely manner?

Q19. How were large differences among/between reviewers of a proposal reconciled?

Q20. What was the overall quality of the external reviews?

1. [If unclear] Were there any questionable reviews?
2. [If unclear] What level of consistency was there between the reviewers?

Q21. Thinking about the external review process overall, what do you think went well, what did not go so well, and how do you think the review process might be improved?

1. Went well:

2. Not so well:
3. Might be improved:

Q22. [Omit for Don] After the external reviews, the DOE offices reviewed the proposals. Please describe to your knowledge how [for OTT/TCF staff:] the different offices [for office contacts:] your office… conducted these reviews.

Q23. In your opinion, what went well and what did not go so well during the office reviews?

1. Went well:
2. Not so well:
3. Might be improved:
4. Was there anything surprising to you about the office reviews?
5. [If not discussed:] How did the 2016 process compare with the 2017 process?

Q24. The next step was the one-day meeting to make final rankings and recommendations for funding. Please briefly sketch how that meeting was conducted.

Q25. In your opinion, what went well and what did not go so well during the one-day meeting?

1. Went well:
2. Not so well:
3. Might be improved:
4. Was there anything surprising to you about the one-day meeting?
5. [If not discussed:] How did the 2016 process compare with the 2017 process?

Q26. The final step was the selection of projects by the Selection Official. In your opinion, what went well and what did not go so well for this review phase?

1. Went well:
2. Not so well:
3. Might be improved:
4. Was there anything surprising to you about the final selection?
5. [If not discussed:] How did the 2016 process compare with the 2017 process?
6. [ASK Don:] Who was the Selection Official (name, title)? Any change from 2016 to 2017?

Review Process for All [ASK ALL]

[If DOE, omit this lead-in. If Labs, read:] Let's move on to talk about the proposal review process.

Q27. What was the quality and timeliness of review comments sent to PIs?

Q28. [Lab] To what extent do you think your lab and the PIs (1) received reviewer comments and (2) found the reviewer comments helpful? (If needed, did the labs and PIs learn from the comments?)

1. Are you aware of whether any PIs of nonselected proposals have submitted or plan to submit again in a subsequent round?
2. [If Labs:] Are you aware of whether any PIs of nonselected proposals built on their TCF submittal to respond to another (non-TCF) funding opportunity?

3. [DOE and Labs, If Yes to either question:] Do you have a sense of whether the PIs of nonselected proposals changed their plans based on reviewer comments? [If Yes:] In what ways?

Q29. This concludes my questions on the review process. Were there any differences between 2016 and 2017 that we didn't discuss?

1. Anything else you would like to add about the review process?

Selection process [ASK ALL]

These next questions relate to the selection and award process.

Q30. From your understanding or experience, after proposals were selected, please walk me through the timeline of how the Labs and project teams were notified, when agreements got finalized, and when funding was awarded. (Probe – vary by PO?)

1. [If review process was delayed in Q14a] To what extent, if any, do delays in announcing selected proposals negatively affect Labs or partners?
2. [If unclear, ask DOE:] Once the projects were selected for awards, what is the process for the TCF program and/or DOE program or technology office to follow up with the Labs and/or project teams? Is this process common across funding opportunities with DOE, or does TCF have its own process?
3. [ASK ALL:] Do all selected projects get TCF agreements finalized in six months?
4. [ASK ALL:] At what point do the Labs typically receive the TCF funds, or how long from announcement to receiving funds, typically?

Q31. [ASK DOE:] To what extent do selected proposals have greater synergies or cross-over among program and technology offices than nonselected proposals? Relatedly, to what extent were such synergies explicitly considered as a factor in proposal selection?

Q32. [ASK DOE:] To what extent do selected proposals have greater cross-Lab teams than nonselected proposals? Relatedly, and like before, to what extent did such teaming arrangements play a role in proposal selection?

Q33. This concludes my questions on the selection process. Were there any differences between 2016 and 2017 that we didn't discuss?

Q34. Anything else you would like to add about the selections?

Execution process [ASK ALL]

Now I'd like to ask about executing the 2016 projects.

Q35. To what extent did project teams change their approach or process in the agreement from what was written in their proposals?

1. [If needed:] Did they do additional customer discovery, or any additional business model development?)

Q36. Did PIs/Labs/project teams run into challenges getting the CRADAs in place within the TCF-specified timeline for project contracting and initiation?

1. Were there any aspects of the TCF that created challenges for CRADA development?
2. What form of CRADA was used (short or long DOE template, other)?
3. Is there anything you can think of that would accelerate the establishment of CRADAs?

Q37. What are the tracking and reporting requirements Labs and project teams must comply with?

1. [If unclear] Briefly what metrics are Labs and project teams required to report?
2. [If unclear:] Who do they report to and how frequently? What type of document?
3. Are there any processes tailored to TCF for tracking TCF expenditures and matched funds (both lab and partner funds)? [If Yes:] Describe.

Q38. Have any TCF projects reached completion?

1. [If Yes:] In your opinion, what is the level of quality of submitted end-of-project reports?
2. Was an end of project report template for format and contents provided/used?
3. [For Labs:] Did you help write or review end of project reports?
4. In your opinion, how effectively do end of project reports convey accomplishments relevant and sufficient for the Lab and DOE to assess attainment of project and TCF goals?

Overall [ASK ALL]

We're just about done, I just have a few high-level questions left.

Q39. What is the role of the TCF-supporting Lab (INL)?

1. What has been your interaction with INL on TCF?
2. What support did you expect?
3. How effective has the support been?
4. [If not effective] What might be improved about TCF processes or INL's activities with respect to INL's role?

Q40. Broadly, what is not working or could be improved in the TCF program from your perspectives?

Q41. In your opinion, how adequate has the support from the TCF program and technology offices been to the Labs and project teams? Why do you say that?

1. Are there areas where Labs and project teams could use more support?
2. Have TCF processes been fair? Transparent? Efficient?

Q42. To what extent, if at all, do TCF and other DOE or OTT programs, such as Energy I-Corps, work together to promote commercialization?

1. Do you think TCF and any of these other efforts work at cross purposes? [If Yes:] Describe.

Q43. Those are all the questions I have for you, is there anything else you think is important for me to know about the TCF program?

D.2.2. National Lab Staff

Introduction

Thank you for making the time to talk with me today. As I mentioned, my firm is working with the Department of Energy to assess the Technology Commercialization Fund or TCF. Your feedback is valuable to help us understand its processes and how well those processes are working for the [DOE offices] Labs and project teams. There are four main sections addressing proposal solicitation, review, selection, and execution. Our interview will take about an hour. I'll be taking notes as we talk, but I'd like to record this conversation to ensure the accuracy of my notes. Is that okay with you?

Any questions for me before we get started?

Background

Q1. First, I'd like to know a little bit about you. What is your title at [DOE or Lab]? What is your role with TCF?

Q2. [If at Lab] Who else at your Lab helps PIs with TCF-related commercialization efforts?

1. [If 1 person] What is their title and office or department at the lab?

Solicitation requirements and process [ASK ALL]

This set of questions are about the solicitation for proposals and funding. Please include in your answers any differences between the 2016 and 2017 solicitations.

Q3. [ASK Don:] About how much advanced notice was given to the labs informing them of when the solicitation will be issued (2016 and 2017)? Do you anticipate any change going forward?

1. [ASK ALL:] PIs/Labs submitted a letter of intent before submitting a proposal. How helpful or useful was that letter of intent process? (If needed, helpful in having a sense of which projects/technologies were applying for funds.)
2. [ASK ALL:] In your opinion, does the timing of the advance notice and the deadline provided by the solicitation give the Labs and project teams enough time to get prepared, obtain partners, and write the proposal?

Q4. What are the most common questions [If DOE:] Labs and project teams have [If Labs] your staff and teams have after reading the proposal guidance?

1. [If unclear] What about the matching funds requirements, is that clear?
2. How common is it for potential proposers to have questions about qualifying partners? [Optional elaboration:] Existing CRADAs are not eligible under this process.

Q5. Let's talk more about partners. What approaches do [If DOE:] Labs and project teams take [If Labs] your staff and teams take to find interested partners? [Probe to get elaborated answer. Perhaps ask if varies by technologies, existing relationships, PIs…]

1. [ASK THE LABS THE FOLLOWING QUESTIONS]

2. Did you have any Topic 1 proposals that included partners that were not contributing funding?
3. [If Yes:] What was your thinking in including them?
4. Were there any differences between Topic 1 and Topic 2 proposals in how you identified or involved partners?

[ASK DON THE FOLLOWING QUESTIONS]

5. About half of the 2016 Topic 1 proposals indicated partners – nonfinancial partners. Were you expecting this?
6. What was your response? Did the inclusion of partners on Topic 1 strengthen proposals?
7. There are no CRADAs for Topic 1 projects. Were there any issues regarding who would own the IP for these projects?

Q6. [If Labs:] Who is typically involved in mounting the TCF proposals – just the PIs and their teams? [Probe to understand the distinct roles]

1. [If unclear:] What support is provided by TTO? Does TTO read the draft and advise?

Q7. Thinking about funding now... What source of non-federal funds [If DOE:] do the Labs use [If Labs] does your Lab use to fund their match for Topic 1 projects?

1. What challenges [If DOE:] do the Labs face [If Labs] does your Lab face in coming up with the matching funds?
2. [Lab] What is the process of deciding how labs fund the match (e.g., is it competitive), and who decides?

Q8. In your opinion, are the topic funding amounts appropriate given TCF's objectives as you understand them?

1. [If no] Why do you say that?

Q9. Would you say the TCF proposal submittal process is more or less difficult than other funding opportunities for technology development projects? Why do you say that?

Q10. [Lab] Were there any problems with sharing proprietary data in the proposals?

Q11. From your understanding, what elements comprise commercial viability? (If needed: technology soundness, comparative advantage, target application, target customers.)

Q12. How appropriate do you think the solicitation requirements regarding commercial viability and approach to commercialization are given TCF's objectives?

1. [If DOE:] To what extent are the proposals typically providing information useful to you in assessing commercial viability? To clarify, we are not asking about typical viability of the technologies, but the quality of the information in the proposals regarding viability.
2. [If Labs:] To what extent are your PIs typically providing information in the draft proposal that you think adequately addresses DOE's need to assess commercial viability? To clarify, we are not asking about typical viability of the technologies, but the quality of the information in the draft proposals regarding viability.
3. [If Labs, if not clear:] Is this something your staff typically needs to help PIs with?

4. [ASK ALL:] Might it be appropriate for proposal requirements to include description of completed customer discovery to clarify commercial viability?
5. [ASK ALL:] And might it be appropriate for proposal requirements to specify that the proposed work scope include additional customer discovery?

Q13. This concludes my questions on the solicitations. Were there any differences between 2016 and 2017 that we didn't discuss?

Q14. Anything else you would like to add about the solicitations?

Review Process for DOE [ASK DOE]

[If DOE, else skip to next section:] Let's move on to talk about the proposal review process. In all of your answers, please discuss any differences between 2016 and 2017.

Q15. First, let me ask directly about differences between 2016 and 2017. What, if any, lessons learned from 2016 resulted in changes in the review process for 2017?

Q16. PIs/Labs submitted a letter of intent so that the TCF group can identify appropriate reviewers. How helpful or useful was that letter of intent process? (If needed, helpful in having a sense of which projects/technologies were applying for funds, helpful in getting appropriate reviewers.)

Q17. How readily was the TCF program able to identify and recruit reviewers?

1. Was the TCF program able to recruit an appropriate number of reviewers?
2. In your opinion, did the technical reviewers have the relevant technical subject matter expertise?
3. In your opinion, did the market reviewers have the relevant market subject matter expertise?
4. Did any reviewers drop out of the process?

Q18. What type of guidance and training, if any, did the TCF provide to reviewers?

1. To what extent do you think the training was effective in meeting the program needs?

Q19. Were the reviewers able to deliver their reviews by the deadlines given to them?

1. [If unclear] Did the review process get delayed? Or did it conclude in a timely manner?

Q20. How were large differences among/between reviewers of a proposal reconciled?

Q21. What was the overall quality of the external reviews?

1. [If unclear] Were there any questionable reviews?
2. [If unclear] What level of consistency was there between the reviewers?

Q22. Thinking about the external review process overall, what do you think went well, what did not go so well, and how do you think the review process might be improved?

1. Went well:
2. Not so well:

3. Might be improved:

Q23. [Omit for Don] After the external reviews, the DOE offices reviewed the proposals. Please describe to your knowledge how [for OTT/TCF staff:] the different offices [for office contacts:] your office … conducted these reviews.

Q24. In your opinion, what went well and what did not go so well during the office reviews?

1. Went well:
2. Not so well:
3. Might be improved:
4. Was there anything surprising to you about the office reviews?
5. [If not discussed:] How did the 2016 process compare with the 2017 process?

Q25. The next step was the one-day meeting to make final rankings and recommendations for funding. Please briefly sketch how that meeting was conducted.

Q26. In your opinion, what went well and what did not go so well during the one-day meeting?

1. Went well:
2. Not so well:
3. Might be improved:
4. Was there anything surprising to you about the one-day meeting?
5. [If not discussed:] How did the 2016 process compare with the 2017 process?

Q27. The final step was the selection of projects by the Selection Official. In your opinion, what went well and what did not go so well for this review phase?

1. Went well:
2. Not so well:
3. Might be improved:
4. Was there anything surprising to you about the final selection?
5. [If not discussed:] How did the 2016 process compare with the 2017 process?
6. [ASK Don:] Who was the Selection Official (name, title)? Any change from 2016 to 2017?

Review Process for All [ASK ALL]

[If DOE, omit this lead-in. If Labs, read:] Let's move on to talk about the proposal review process.

Q28. What was the quality and timeliness of review comments sent to PIs?

1. [If review process was delayed in Q18a] To what extent, if any, do delays in announcing selected proposals negatively affect Labs or partners?

Q29. [Lab] To what extent do you think your lab and the PIs (1) received reviewer comments and (2) found the reviewer comments helpful? (If needed, did the labs and PIs learn from the comments?)

1. Are you aware of whether any PIs of nonselected proposals have submitted or plan to submit again in a subsequent round?

2. [If Labs:] Are you aware of whether any PIs of nonselected proposals built on their TCF submittal to respond to another (non-TCF) funding opportunity?
3. [DOE and Labs, If Yes to either question:] Do you have a sense of whether the PIs of nonselected proposals changed their plans based on reviewer comments? [If Yes:] In what ways?

Q30. This concludes my questions on the review process. Were there any differences between 2016 and 2017 that we didn't discuss?

1. Anything else you would like to add about the review process?

Selection process [ASK ALL]

These next questions relate to the selection and award process.

Q31. From your understanding or experience, after proposals were selected, please walk me through the timeline of how the Labs and project teams were notified, when agreements got finalized, and when funding was awarded. (Probe – vary by PO?)

1. [If unclear, ASK DOE:] Once the projects were selected for awards, what is the process for the TCF program and/or DOE program or technology office to follow up with the Labs and/or project teams? Is this process common across funding opportunities with DOE, or does TCF have its own process?
2. [ASK ALL:] Do all selected projects get TCF agreements finalized in six months?
3. [ASK ALL:] At what point do the Labs typically receive the TCF funds, or how long from announcement to receiving funds, typically?

Q32. [ASK DOE:] To what extent do selected proposals have greater synergies or cross-over among program and technology offices than nonselected proposals? Relatedly, to what extent were such synergies explicitly considered as a factor in proposal selection?

Q33. [ASK DOE:] To what extent do selected proposals have greater cross-Lab teams than nonselected proposals? Relatedly, and like before, to what extent did such teaming arrangements play a role in proposal selection?

Q34. This concludes my questions on the selection process. Were there any differences between 2016 and 2017 that we didn't discuss?

Q35. Anything else you would like to add about the selections?

Execution process [ASK ALL]

Now I'd like to ask about executing the 2016 projects.

Q36. To what extent did project teams change their approach or process in the agreement from what was written in their proposals?

1. [If needed:] Did they do additional customer discovery, or any additional business model development?)

Q37. Did PIs/Labs/project teams run into challenges getting the CRADAs in place within the TCF-specified timeline for project contracting and initiation?

1. Were there any aspects of the TCF that created challenges for CRADA development?
2. What form of CRADA was used (short or long DOE template, other)?
3. Is there anything you can think of that would accelerate the establishment of CRADAs?

Q38. What are the tracking and reporting requirements Labs and project teams must comply with?

1. [If unclear] Briefly what metrics are Labs and project teams required to report?
2. [If unclear:] Who do they report to and how frequently? What type of document?
3. Are there any processes tailored to TCF for tracking TCF expenditures and matched funds (both lab and partner funds)? [If Yes:] Describe.

Q39. Have any TCF projects reached completion?

1. [If Yes:] In your opinion, what is the level of quality of submitted end-of-project reports?
2. Was an end of project report template for format and contents provided/used?
3. [For Labs:] Did you help write or review end of project reports?
4. In your opinion, how effectively do end of project reports convey accomplishments relevant and sufficient for the Lab and DOE to assess attainment of project and TCF goals?

Overall [ASK ALL]

We're just about done, I just have a few high-level questions left.

Q40. What is the role of the TCF-supporting Lab (INL)?

1. What has been your interaction with INL on TCF?
2. What support did you expect?
3. How effective has the support been?
4. [If not effective] What might be improved about TCF processes or INL's activities with respect to INL's role?

Q41. Broadly, what is not working or could be improved in the TCF program from your perspectives?

Q42. In your opinion, how adequate has the support from the TCF program and technology offices been to the Labs and project teams? Why do you say that?

1. Are there areas where Labs and project teams could use more support?
2. Have TCF processes been fair? Transparent? Efficient?

Q43. To what extent, if at all, do TCF and other DOE or OTT programs, such as Energy I-Corps, work together to promote commercialization?

1. Do you think TCF and any of these other efforts work at cross purposes? [If Yes:] Describe.

Q44. What are the most important ways your lab has benefitted from participation in TCF? (probe: Does TCF help support your mission?)

Q45. Those are all the questions I have for you, is there anything else you think is important for me to know about the TCF program?

D.2.3. Principal Investigators

Introduction

Thank you for making the time to talk with me today. As I mentioned, my firm is working with the Department of Energy, Office of Technology Transitions to assess the Technology Commercialization Fund or TCF. The purpose of our conversation today is to see how participation in the program is going from a PI perspective. Our conversation should take about fifteen minutes. I'll be taking notes as we talk, but I'd like to record this conversation to ensure the accuracy of my notes. Is that okay with you?

Any questions for me before we get started?

Solicitation requirements and process [ASK ALL]

The first set of questions are about the solicitation process and requirements.

Q1. After you read the solicitation, was the purpose of the Technology Commercialization Fund solicitation easy to understand? Why do you say that?

Q2. And how about the process of applying to TCF, was that easy to understand? Why do you say that?

Q3. What was your impression of the merit review criteria?

1. [If not mentioned] What did you think of the commercial impact criteria? (If needed: It was intended to assess the promise of technology commercialization and market understanding).
2. [If not mentioned] What did you think of the technical merit criteria? (If needed: Those were about technology scalability, project goals, and team capabilities).

Q4. What would you say was the level of interest in the TCF program among PIs at your lab? Why do you say that?

1. [If unclear] Why were you interested in TCF?
2. [If not mentioned] How does the level of interest in TCF you observed among your colleagues compare with their responses to other funding opportunities?

Suggestions for Improvement [ASK ALL]

My last few questions address opportunities for improvement.

Q5. In your opinion, how adequate was the support provided by the TCF program team and the Program Offices as you and your lab pursued the TCF opportunity? Why do you say that?

Q6. Are there areas where you think project teams could use more support, at any point in the process, from initial solicitation through contracting and project execution?

Q7. Broadly, what is not working well or could be improved in the TCF program from your perspectives?

Q8. Overall, what is working well with the TCF program?

Closing [ASK ALL]

Q9. [If private sector partner] As part of our evaluation effort, we also want to speak with the private-sector partners to ask them a short set of similar questions. Would you mind providing contact information for your partner, so we can reach out to them? [Confirm name, firm, phone (if possible), and email address.]

Q10. Those are all the questions I have for you. Is there anything else you think is important for me to know about the TCF program?

Thank you for your time and your feedback today.

D.2.4. Private Sector Partners

Introduction

Thank you for making the time to talk with me today. As I mentioned, my firm is working with the Department of Energy, Office of Technology Transitions to assess the Technology Commercialization Fund or TCF. The purpose of our conversation today is to see how participation in the program is going from the perspectives of private industry partners. Our conversation should take about fifteen minutes. I'll be taking notes as we talk, but I'd like to record this conversation to ensure the accuracy of my notes. Is that okay with you?

Any questions for me before we get started?

Solicitation requirements and process [ASK ALL]

The first set of questions are about the solicitation process and requirements.

Q1. How did you learn of the Technology Commercialization Fund opportunity?

1. [If unclear] Did PI or lab staff approach partner?
2. [If unclear] Did partner have a prior relationship with PI or lab?

Q2. Why were you interested in collaborating with [PI NAME] to apply for the Technology Commercialization Fund?

Q3. Did the fact that the federal government matched your contribution influence your decision to support this technology?

Q4. What's the likelihood you would have worked with [PI NAME] on this technology, if the TCF program did not exist?

Q5. Did you contribute to the proposal writing at all?

Q6. [If Q5= yes] Was the purpose of the Technology Commercialization Fund easy to understand after you read the solicitation information? Why do you say that?

Q7. [If Q5= yes] And how about the process of applying to TCF, was that easy to understand? Why do you say that?

Q8. [If Q5= yes] What was your impression of the merit review criteria?

1. [If not mentioned] What did you think of the commercial impact criteria? (If needed: It was intended to assess the promise of technology commercialization and market understanding).
2. [If not mentioned] What did you think of the technical merit criteria? (If needed: Those were about technology scalability, project goals, and team capabilities).

Suggestions for Improvement [ASK ALL]

We're almost done. Just a few questions left.

Q9. How has it been going so far collaborating with [PI NAME] and the lab as they continue the technology research?

Q10. Is there anything about TCF that is not working well or that could be improved, from your perspective?

Q11. How about getting the CRADA in place? Did that go smoothly?

Q12. [If time allows] Overall, what's working well with the TCF program?

Closing [ASK ALL]

Q13. Those are all the questions I have for you. Is there anything else you think is important for me to know about the TCF program from your perspectives?

Thank you for your time and your feedback today.