Argonne NATIONAL LABORATORY

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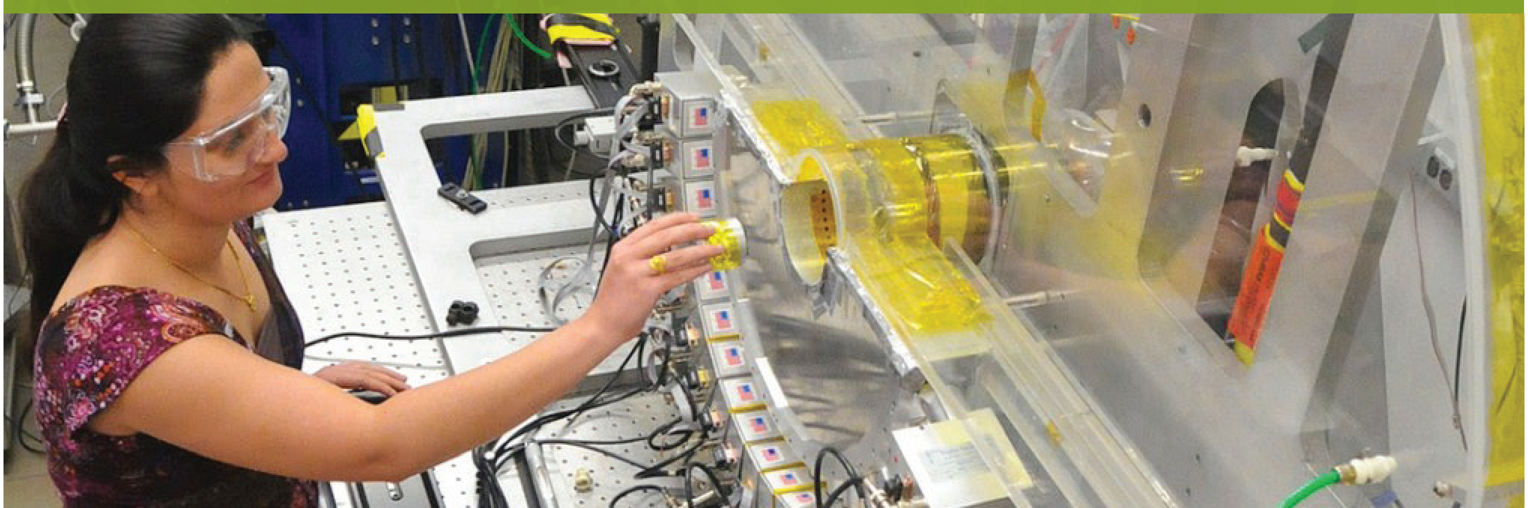
Enhancing National Laboratory Partnership and Commercialization Opportunities



ENHANCING NATIONAL LABORATORY PARTNERSHIP AND COMMERCIALIZATION OPPORTUNITIES

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Diane Palmintera, Author

Damon Porter, Research Analyst

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FOREWORD

National laboratories play a critical role in building the nation's innovation capacity and driving our economy. At Argonne National Laboratory (Argonne), we are working on developing a reliable, efficient and secure electrical grid, and other technologies ranging from transportation vehicles to semiconductor devices to cancer-fighting drugs that will change people's lives, nationally and globally. In order for many national laboratory innovations to be truly impactful, they must be commercialized and distributed through the marketplace, and Argonne works closely with its academic, industry and national laboratory partners to do so.

At Argonne, we strive to do a better job of working with our collaborators to transition the Laboratory's research and development (R&D) projects from lab to market, mutually benefiting all partners and always keeping the public benefit foremost. We are mindful that other national laboratories, academic and research institutions also are trying to find ways to accelerate and transition their innovations, and some are experimenting with initiatives that could be adapted by others. In order to learn more about these innovative initiatives, we commissioned Innovation Associates to explore some promising models that could be adapted for use. Several national laboratories very generously shared their knowledge with us, and by releasing portions of the Argonne report nationally, we wish to share what we have learned with others.

The U.S. Department of Energy (DOE), which funds Argonne and 16 other national laboratories, is increasingly reaching out to the laboratories to better understand impediments to technology transfer and commercialization and to identify potential remedies. Through the DOE Commission to Review the Effectiveness of the National Energy Laboratories, a number of barriers were brought to light and recommendations made. We applaud the DOE and Administration for these efforts and encourage them to continue pursuing a better understanding of public-private partnerships, experimenting with new tools, and supporting individual national laboratory efforts that test new mechanisms intended to accelerate and transition R&D. We further call on other national laboratories to join us and work together to explore new ways of collaborating and commercializing R&D that benefits all.

Peter Littlewood
Director, Argonne National Laboratory

PREFACE

This report discusses challenges to national laboratory partnerships and commercialization, and highlights selected DOE and national laboratory initiatives that address these challenges. Partnership and commercialization initiatives are ever evolving as laboratories increasingly experiment with new ideas and as these ideas are tested and refined. We encourage DOE and individual laboratories to continuously provide and update information on current and emerging initiatives in national laboratories, as well as those in universities, corporations and organizations that might be applied to the laboratory setting.

We offer a number of recommendations that could add value to the innovative initiatives featured, and provide DOE and national laboratories with other suggestions. In addition to the recommendations found in this report, a White House sponsored Lab-to-Market Summit that was co-chaired by the author of this report provided wide-sweeping recommendations. Among these recommendations is a call for a federal Office of Innovation and Federal Technology Partnerships. It also calls for devoting a greater portion of R&D resources to accelerating and commercializing federal sponsored R&D, and incentivizing greater collaboration with the external investment, entrepreneurial, economic development and manufacturing communities. Further recommendations related to university partnerships and commercialization, and their role in regional innovation and entrepreneurial ecosystems, can be found in previous reports by Innovation Associates.

This report, generously supported by Argonne National Laboratory, already has contributed to new initiatives that are being launched at Argonne. We hope that the report will contribute to other national laboratory initiatives that will “raise the bar” even higher in promoting private sector partnerships, commercialization and collaboration.

Diane L. Palmintera
President, Innovation Associates Inc.

ACKNOWLEDGEMENTS

Innovation Associates would like to thank Argonne for sponsoring this important work. We particularly would like to thank Argonne Director, Peter Littlewood, for his leadership and vision in national laboratory partnering and commercialization that led to this work. His strong interest in advancing private sector and other partnerships was the basis for this project and report. Greg Morin, Argonne's Director for Strategy and Innovation, provided oversight and input on the project, and we appreciate his thoughtful comments and helpful input throughout the project. We want to acknowledge the many Argonne division directors and staff, particularly Jeffrey Chamberlain, Director of Argonne Collaborative Center for Energy Storage Science (ACCESS), and the University of Chicago leadership, including Donald H. Levy, former Vice President for Research and for National Laboratories, as well as other Argonne and University directors for their time and input. We hope that the resulting information and recommendations in this report will be helpful in advancing Argonne's strategic direction in partnering and commercialization. We also want to thank several directors and staff from the U.S. Department of Energy headquarters who provided information and helpful discussions, including representatives from the Office of Science, Energy Efficiency and Renewable Energy Office, Office of Technology Transitions, Advanced Manufacturing Office, and Advanced Research Projects Agency-Energy.

We especially appreciate the many program and organization directors from the exemplars in this report who took substantial time to provide us with information, insight, review and comments. In the spirit of sharing knowledge with other national laboratories, the representatives openly provided detailed information, sample partnership agreements and other material that will help Argonne and other national laboratories implement innovative programs to promote industry partnerships and commercialization. We interviewed representatives from some additional national laboratory programs and organizations that do not appear as exemplars in this report. These representatives contributed valuable information and an outside perspective that are reflected in the report's discussion and recommendations to Argonne.

Many of the national laboratory, university, organization and DOE representatives interviewed for this project and report are listed in Appendix A. We hope that the report also provides them with useful examples and insights that will enhance their own programs and practices.

EXECUTIVE SUMMARY

INTRODUCTION

National laboratories are innovation powerhouses. They conduct wide-ranging research and development (R&D) on clean energy, national security, supercomputing, nanotechnology, materials and other scientific and engineering research, pushing technological breakthroughs and expanding new frontier boundaries. The laboratories have been responsible for research leading to the internet, integrated circuits, optical digital recording technology, maglev trains, proton accelerators, and many other technologies that make people's lives better and safer. Funded by the U.S. Department of Energy (DOE), the 17 laboratories are all, except for one, managed by nonprofit and private sector contractors such as Battelle Memorial Institute (Battelle), Lockheed Martin, University of California, and University of Chicago.[1] With an annual budget totaling more than $11 billion, and employing 55,000 researchers and staff, they are the nation's leading technology discovery and innovation force.

Partnerships with industry and the promotion of technology transfer and commercialization are increasingly important in insuring the widespread dissemination and deployment of national laboratory innovations. In order to enhance industry partnerships, technology transfer and commercialization, Argonne National Laboratory (Argonne) contracted with Innovation Associates (IA) of Reston, VA to identify exemplars from national laboratories that could serve as models for Argonne and other national laboratories. IA identified programs and practices at several national laboratories, and additional exemplars from universities and other institutions. Based on this work and previous National Science Foundation work on universities, IA provided suggestions for adapting selected exemplars; in some cases, IA suggested value-added elements.

Importance of Industry Partnerships, Technology Transfer and Commercialization

Innovation is a key component of U.S. economic prosperity, and technology transfer and commercialization are key drivers of successful innovation. Both the executive and legislative branches of the federal government set policies supporting industry partnering to promote commercialization of innovative technologies. Congress in the 1980's laid the foundation

[1] Many contractors are incorporated as separate LLCs, sometimes in collaboration with others such as Battelle and the University of Tennessee that have formed UT-Battelle LLC to manage Oak Ridge National Laboratory.

through several legislative acts,[2] and the executive branch more recently undertook numerous efforts to promote technology transfer and commercialization. In an October 2011 Presidential Memorandum, President Obama set a goal of fostering innovation "by increasing the rate of technology transfer and the economic and societal impact from federal research and development (R&D) investments."[3] The Memorandum committed each executive department and agency involved in conducting research to improve commercialization and technology transfer results, with an aim of significant improvement over five years. This call to action was echoed by DOE Secretary Ernest Moniz who, during his 2013 nomination hearing stated that the DOE could do more in the technology transfer arena, by lowering barriers and working collaboratively with universities and the private sector.[4] In early 2015, the Secretary announced the launch of the Office of Technology Transitions, enhancing a prior office to more actively promote commercialization of DOE research.

Addressing Barriers to Technology Transfer and Commercialization

In spite of the efforts to promote technology transfer and commercialization at the national laboratories, significant barriers remain. A recent report produced jointly by the Information Technology and Innovation Foundation (ITIF), Center for American Progress (CAP) and the Heritage Foundation described the persistence of "a number of policy, budgeting, cultural, and institutional barriers to interacting with industry."[5] A national expert panel at the White House Lab-to-Market, Inter-Agency Summit co-chaired by IA's President, noted that commercialization of discoveries from federal agency research "has largely been an after-thought."[6] The DOE's Secretary of Energy Advisory Board (SEAB) National Laboratory Task Force found that DOE's centralized approach to promoting technology transfer at the national laboratories created barriers to policies intended to promote technology transfer,[7] and an interim report by the DOE Commission to Review the Effectiveness of the National Energy Laboratories found that support

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[2] Congressional Acts included the Stevenson-Wydler Technology Innovation Act of 1980 and Bayh-Dole Act of 1980.

[3] White House Office of the Press Secretary, *Presidential Memorandum—Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Businesses*, U.S. Government Publishing Office, October 28, 2011, 1. http://www.gpo.gov/fdsys/pkg/DCPD-201100803/pdf/DCPD-201100803.pdf.

[4] *Hearing to Consider the Nomination of Dr. Ernest Moniz to be the Secretary of Energy, Before the Committee on Energy and Natural Resources, United States Senate*, 113th Cong. 17 (2013) (statement of Ernest Moniz). 21. http://www.gpo.gov/fdsys/pkg/CHRG-113shrg80930/pdf/CHRG-113shrg80930.pdf.

[5] Matthew Stepp, Sean Pool, Nick Loris, and Jack Spencer, *Turning the Page: Reimagining the National Labs in the 21st Century Innovation Economy*, (The Information Technology and Innovation Foundation, The Center for American Progress, The Heritage Foundation, June 2013), 42.

[6] National Expert Panel, "Lab-to-Market Inter-Agency Summit: Recommendations from the National Expert Panel," (Panel Recommendations at the White House Conference Center, Washington, DC, May 20, 2013), 2. ; http://innovationassoc.com/files/WH.L2MSummit.Recommendations.FINAL.Aug.09.2013.-2.pdf

[7] Secretary of Energy Advisory Board, *Report of the Secretary of Energy Task Force on DOE National Laboratories*, (US Department of Energy: June 17, 2015), 29. http://www.energy.gov/seab/downloads/interim-report-task-force-doe-national-laboratories.

for technology transfer was "inconsistent across the laboratories and across the DOE program offices."[8] An earlier U.S. Government Accountability Office (GAO) report found that a "lack of flexibility" in negotiating technology transfer agreements was a primary challenge to expanding commercialization of laboratory technology.[9] The Institute for Defense Analysis' Science and Technology Policy Institute (STPI) report found that laboratory researchers "may lack the knowledge, ability, and incentives necessary" to undertake the research and business activities necessary to promote technology transfer and commercialization.[10] Researchers at national laboratories are more restricted than those at universities regarding the types of activities that they can engage in, and the extent of that engagement. University researchers have more flexibility with regard to launching startups and taking equity in those startups, and they are permitted greater leeway with regard to outside consulting.[11] We can summarize the major barriers to national laboratory technology and commercialization as (a) DOE over-centralization; (b) inconsistency and mixed messages regarding the importance of technology transfer, and what is permitted; (c) aversion to risk; (d) lack of flexibility; (e) lack of researcher commercialization capacity and incentives; and (f) underfunded support for technology transfer and commercialization.

DOE, particularly the Office of Energy Efficiency and Renewable Energy (EERE), has recently worked to address some of these barriers through a series of pilots and programs. Energy Frontier Research Centers (EFRCs) are driving collaboration between university, industry, non-profit, and national laboratory researchers. Energy Innovation Hubs, such as the Joint Center for Energy Storage Research (JCESR) and the Critical Materials Institute (CMI) are investing in basic research that is linked to initial product development, and intended to bring together expertise from DOE national laboratories, universities, and industry. Agreements for Commercializing Technology (ACT) is a pilot program that provides an alternative technology transfer mechanism intended to create more flexible and expeditious private sector agreements. Lab-Corps, a pilot based on the National Science Foundation's successful I-Corps, is designed to educate researchers on commercialization and entrepreneurial practices.

Some of the most impressive attempts to improve partnerships and commercialization have come from the national laboratories themselves. These programs and practices include the

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[8] *Interim Report of the Commission to Review the Effectiveness of the National Energy Laboratories*, (US Department of Energy: February 27, 2015), vi. http://energy.gov/labcommission/downloads/interim-report-commission-review-effectiveness-national-energy-laboratories.

[9] Government Accountability Office, "Technology Transfer: Clearer Priorities and Greater Use of Innovative Approaches Could Increase the Effectiveness of Technology Transfer at Department of Energy Laboratories" (2009), available at http://www.gao.gov/assets/300/290963.pdf.

[10] Mary Elizabeth Hughes, Susannah Vale Howieson, Gina Walejko, Nayanee Gupta, Seth Jonas, Ashley T. Brenner, Dawn Holmes, Edward Shyu, and Stephanie Shipp, *Technology Transfer and Commercialization Landscape of the Federal Laboratories*, Institute for Defense Analyses Science & Technology Policy Institute (IDA Paper NS P-4728: June 2011), 26.

[11] Ibid., p. 29.

National Renewable Energy Laboratory's (NREL's) Industry Innovation Showcase, Lawrence Berkeley National Laboratory's (Berkeley Lab's) Cyclotron Road, Pacific Northwest National Lab's (PNNL's) "use permit" model leading to ACT, Oak Ridge National Laboratory's (ORNL's) creative Manufacturing Demonstration Facility, Sandia National Laboratory's (SNL's) Science and Technology Park and entrepreneurial leave program, and others.

Some of the most promising recent experiments have involved the creation of external nonprofit organizations affiliated with national laboratories including Berkeley Lab's CalCharge and Los Alamos National Lab's (LANL's) New Mexico Consortium (NMC). Creating an external, nonprofit organization is one way that a national laboratory can facilitate more flexible, expedient external partnerships. Ideally, the organization not only adds value through intermediary mechanisms and services, it also ultimately enhances the laboratory's R&D and internal culture. It does so by providing the opportunities for more and broader engagement with corporate and other partners. For many years, universities have created nonprofit organizations to carry out technology transfer and certain private sector and philanthropic interactions. They have done so to create an "arm's length" distance that provides greater indemnification and flexibility in dealings with the private sector. External organizations offer one way in which national laboratories can more effectively (a) reduce risk; (b) increase flexibility and speed to market; (c) pursue and leverage broader research interests; (d) connect with the region's innovation and entrepreneurial (I&E) ecosystem; and (e) add value to the laboratory's R&D and innovation culture.

Developing Affiliated Organizations and Enhancing National Laboratory Programs

A variety of external organizations and internal programs facilitate industry R&D partnerships and successfully promote commercialization. There is no one right way to achieve greater partnership and commercialization goals. The best approach involves adapting elements from various programs and practices that address a specific laboratory's vision and environment.

National laboratory-affiliated organizations are a relatively new and evolving concept. Thus, it is important to recognize that any new organization is experimental, requiring patience and flexibility to adjust to evolving demands, circumstances and goals. Whether developing a new organization or implementing enhanced practices within the laboratory, it is important to keep in mind that successful programs and practices such as those described in this report, are shaped by multiple factors that are not necessarily common across institutions. The national laboratory's leadership is one such factor. Where there is a national laboratory director that supports technology transfer, commercialization and entrepreneurship, there is likely to be greater experimentation and innovation. National laboratories' partnership and commercialization programs are shaped, in part, by the type of R&D that they perform and their funders. DOE laboratories that are funded by EERE or have major programs funded by EERE, conduct research that is closer to market than those funded mainly by DOE Office of Science (OS), and therefore tend to be better positioned to promote technology transfer and entrepreneurship. The laboratory's management and operations (M&O) contractor also plays a potentially important role. Some laboratory contractors such as Battelle and the University of California (UC) system have emphasized commercialization and entrepreneurship more than others; in some cases, using their contractor fees and additional in-kind support to help create and sustain innovative initiatives. This support has helped underpin initiatives such as the LANL affiliated NMC, ORNL's technology transfer activities, and Berkeley Lab's Cyclotron Road and affiliated CalCharge. State government commitment to leveraging national laboratory R&D for commercialization and economic development also has played a role in underpinning the Berkeley Lab initiatives in California, and those of SNL and LANL in New Mexico. The laboratory and affiliated organization also will be affected by the regional ecosystem in which it is located. Berkeley Lab has benefitted from being located in the rich I&E ecosystem of Silicon Valley, and has leveraged the region's network to support its innovative initiatives.

These various conditions notwithstanding, there are lessons that can be gleaned from exemplars, and specific elements that can be adapted. The following national laboratory, university and other institutional exemplars provide national laboratories with some excellent models from which to draw adaptable elements.

Linking Corporate Members to National Laboratory R&D: CalCharge -- Berkeley Lab's affiliated organization, CalCharge, is an excellent example of a closely linked, nonprofit organization that facilitates laboratory-industry R&D and technology transfer. In 2012, Berkeley Lab and the California Clean Energy Fund (CalCEF) partnered to create CalCharge as a public-private partnership intended to bring together California's battery technology companies with government and academic resources to accelerate the commercialization and market adoption of energy storage technologies. CalCharge is an LLC that is a wholly owned for-profit subsidiary of CalCEF Catalyst. It is a membership organization that by late 2015 had 16 members including 12 corporations representing a mix of startups and major corporations; others were national laboratories, universities and unions. CalCharge's major feature is its Master Services Agreement (an umbrella CRADA) with Berkeley Lab that permits CalCharge members access to Berkeley Lab without negotiating individual contracts. The scope of the CRADA is broadly defined, encompassing energy storage technologies and, in order for projects to be covered under the Master Services Agreement, they must stay within that parameter. The critical difference is that Berkeley

Lab's CRADA is with CalCharge and not the individual member. In this way, CalCharge has been able to expand its reach to private sector members and expedite R&D agreements beyond that which could be done through traditional CRADAs. By late 2015 CalCharge already had executed this type of agreement with two additional laboratories, and had plans to bring in additional laboratories, universities, and private sector members.

Leveraging University-National Laboratory Collaboration: NMC -- The Consortium is a nonprofit 501(c)(3) organization fostered by and affiliated with LANL. It was established by the three New Mexico (NM) research universities - University of New Mexico, New Mexico State University and New Mexico Tech, and has academic standing for the purpose of federal and other grants. The academic, nonprofit standing allows NMC to actively seek and receive grants from a variety of federal agencies and philanthropic foundations, and gives LANL researchers who work on NMC projects access to grants that otherwise would not be available to them. Staffing agreements between NMC and LANL can be structured as an "outside activity" or a "joint appointment" which facilitate shared researcher engagement. The Consortium conducts about $10 million of research per year, about two-thirds of which is funded by (non-DOE) federal agencies and one-fourth to one-third by philanthropies. NMC interfaces with LANL and academic institutions through LANL's National Security Education Center. LANL provides a base of funding from its overhead to help support NMC administrative costs, education and program development activities, and provides additional in-kind professional support. NMC also owns a Biological Laboratory, and LANL subcontracts for access to that Laboratory.

Promoting Laboratory-Industry Partnerships: ORNL's Manufacturing Demonstration Facility (MDF) -- DOE EERE's Advanced Manufacturing Office (AMO) established the MDF at ORNL in order to develop and accelerate advanced manufacturing innovations that could be more rapidly deployed in the marketplace. It is composed of a main facility located on the ORNL campus, and two nearby offsite locations. Most of MDF's R&D involves industry collaborations, and in many cases industry representatives work alongside ORNL researchers. One industry collaboration involves exploratory technologies funded through an EERE AMO project that involves open calls and a two-phase approach: an exploratory phase and development phase, both requiring industry match. In 2015, EERE's AMO developed a unique program opportunity for teams of university professors and their students to engage in additive manufacturing research at MDF. The "Research for Additive Manufacturing Program-University Partnerships" (RAMP-UP) will select 10 university teams to engage in collaborative research projects in additive manufacturing that align with MDF's core projects. MDF received national and international acclaim for its work with Cincinnati Inc. in producing a 3-D printed automobile. It is now working with Local Motors in Tennessee to produce a 3-D car, and working with the entire supply chain on production. The Institute for Advanced Composites Manufacturing Innovation (IACMI), the fifth designated National Manufacturing Innovation Institute (NMII), and MDF are closely tied together. IACMI's CEO is also the Director of MDF and ORNL's Advanced Manufacturing Office. IAMCI is a $250+ million public-private consortium involving 122 companies, nonprofits, universities and research laboratories, led by the University of Tennessee, Knoxville.

Accelerating National Laboratory Innovations: Cyclotron Road -- Launched by Berkeley Lab in July 2014, Cyclotron Road provides support to innovators working to develop and commercialize clean energy technologies. Cyclotron Road competitively selects a small cohort of energy related innovators from across the country and embeds them in Berkeley Lab. The program provides them with up to two years support in the form of a living stipend and access to Berkeley Lab facilities, tools, and expertise. Cyclotron Road staff provide targeted mentorship on technology and manufacturing challenges, and networking connections to internal and external experts who can serve as advisors, collaborators, and potential commercial partners and investors. During their time as innovators at the Laboratory, they are expected to identify financing partners for next stage development and commercialization. The Cyclotron Road competition is open to any U.S. citizen, and projects must have the potential for long-term impact in enabling materials and manufacturing-based products and processes that advance DOE's mission. Cyclotron Road's pilot phase (2014-16) involves eight innovators conducting research in six projects spanning various "hard" energy technologies. The pilot program initially was structured to support the innovators by hiring them as Berkeley Lab temporary employees. This structure was problematic because any new intellectual property developed by the innovators would by default be owned by the Laboratory. In late 2015, Berkeley Lab formulated a proposed new organizational structure in which the innovators would partner with the Laboratory under an umbrella CRADA. At the writing of this report, the program structure still was evolving. Cyclotron Road's value is that it provides a resource base to support researchers in developing products and processes that generally are too applied for typical academic or national laboratory research, and yet too early stage to be supported by traditional venture capital. It is an innovative way to combine external entrepreneurial ideas and innovations with national laboratory resources.

Facilitating Philanthropic Funding: Berkeley Lab Foundation -- In 2013, Berkeley Lab's M&O contractor, UC, established the Berkeley Lab Foundation as a separate nonprofit organization to provide a way for philanthropic and other contributions to fund Berkeley Lab research. A donor has committed a $10 million donor endowment to establish the

Foundation, and while the payout from that endowment builds, UC provides funding from its laboratory fee to cover the operating costs of the Foundation. Berkeley Lab Foundation is an official "support group" within the UC system, giving the University responsibility for oversight and management of the Foundation's funding. By the end of 2015, there were three major gifts to the Foundation, with a fourth gift forthcoming. The separate foundation structure offers certain advantages over Berkeley Lab or UC receiving philanthropic funding. For example, the funding associated with two of the philanthropic contributions/loans was made through the Berkeley Lab Foundation rather than given directly to Berkeley Lab or UC because they were considered somewhat risky, and additionally could be construed as potential "augmentation" which is not allowable under DOE funding. Moreover, the Laboratory has higher overhead costs and while UC has the power to waive overhead costs for philanthropy, the Berkeley Lab cannot. Philanthropic funding thus far has been used mainly for major laboratory equipment that will help establish the Laboratory's prominence in specific technological areas.

Promoting Public-Private Partnerships: NREL Innovation Incubator (IN2) -- IN2 is a joint program conducted by NREL with Wells Fargo. It combines external entrepreneurial talent with the Laboratory's R&D to develop, test and apply innovations to commercial buildings. Wells Fargo funded NREL with $10 million over five years to launch the joint program which identifies and funds entrepreneurs to work with experts from national laboratories, universities and regional accelerators. NREL intends to employ this public-private partnership to bridge the gap between national laboratory R&D and the marketplace. NREL used an ACT agreement to facilitate this partnership.

Showcasing National Laboratory Innovations: NREL's Industry Growth Forum -- The Forum is a well-known, 28 year annual event featuring presentations from emerging clean energy companies, as well as organized networking opportunities and panels. Private, one-on-one meetings are organized between startup companies and potential investors. Presenters can win commercialization services from NREL in addition to potential investment capital from private investors. The Forum receives funding from a variety of public and private sponsors, including Wells Fargo and the State of Colorado's Energy Office. Since 2003, companies presenting at the Forum have raised financing worth more than $4 billion.

Showcasing New Mexico's Innovations: Technology Ventures Corporation (TVC) -- TVC was founded as a 501(c)(3) nonprofit charitable foundation by Lockheed Martin in 1993, as part of Lockheed's M&O contract for SNL. TVC was created to commercialize federally funded technologies, and does not charge fees or take equity compensation for its services.

The organization's operational costs are funded by a Lockheed Martin grant, and TVC receives additional grants from federal agencies for related work. TVC accepts seed and early-stage companies competitively, and mentors and showcases them at its annual Deal Stream Summit. One-third of all companies who present at TVC's Summit have received funding. Lockheed reports that TVC's efforts have helped create more than 117 companies and created 13,500 jobs; its work has been key to the production of more than $1.2 billion in venture capital investments.

Facilitating Access to University Research: Massachusetts Institute of Technology (MIT) Industrial Liaison Program (ILP) -- The ILP is a portal to MIT's researchers, providing access and value-added services for corporate clients. Established in 1948, it was developed to strengthen relationships between MIT and corporations. Operating as part of MIT's Office of Corporate Relations, it is a branded membership program that now involves 230 companies. These member companies account for about 40 percent of all corporate gifts and single-sponsored research expenditures at MIT. At any given time, about one-third of ILP members are actively sponsoring research at MIT. Core activities for members involve Industrial Liaison Officers developing an action plan, providing help with coordinating research management, and sometimes help in assembling multi-disciplinary teams. ILP activities additionally provide access to MIT's entrepreneurial community through various events and through MIT's database of startups. Other membership benefits include information and events in technology areas, discussing management strategies and facilitating recruitment of MIT students. ILP's most important services are that it serves as a single point of contact for corporations and provides individualized plans of engagement.

Commercializing University R&D: Arizona Technology Enterprises (*AzTE*) -- Arizona State University (ASU) created AzTE in 2003 to increase the flexibility and speed of ASU's technology tranfer operations. AzTE was established as an Arizona LLC with the ASU Foundation as its sole member; AzTE additionally has a wholly owned for-profit LLC. The organization has evolved through several iterations, starting out as a unit within the University, reorganized as a separate legal entity to perform technology transfer using a venture capital structure, and now restructured to provide a more "balanced" technology transfer approach focused on generating longer-term industrial partnerships and research engagements. In addition to traditional technology transfer services involving invention disclosures, patenting and licensing, AzTE provides services for startups including introductions to mentors, entrepreneurs-in-residence and potential investors. Other resources linked to AzTE's efforts include the University's Entrepreneurship and Innovation program in which faculty inventors are matched with one of about 100 mentors. Another program, the Furnace Accelerator provides incubation, acceleration funding and mentoring to entrepreneurs who participate in a nine-month accelerator experience culminating in a Demo Day where teams pitch business plans to investors. AzTE has developed a marketing strategy that includes a team review of University innovations and detailed market assessments mainly targeting small- and mid-sized enterprises. Since AzTE's founding in 2003, the ASU's faculty has formed more than 84 startups and has been issued over 600 patents. After the formation of AzTE, energy-related invention disclosures increased ten-fold.

Accelerating University Innovations: MIT Deshpande Center -- Established in 2002 through a gift from philanthropists Gururaj "Desh" and Jaishree Deshpande, the Center gives MIT researchers the funding and tools to bring innovative technologies from lab to market in the form of breakthrough products and startup companies. MIT faculty, student and other researchers with principal investigator status are eligible for a grants and services. The program's staff carries out several core activities: educating grant recipients about the innovation process; coaching grantees on how to commercialize their inventions and launch startup companies; providing research teams with mentoring and guidance from investors, startup specialists and entrepreneurs; and nurturing MIT's I&E ecosystem. The Deshpande Center grant program is conducted in two phases: Ignition Grants provide $50,000 for an invention which is at an early stage; Innovation Grants provide $50,000 to $150,000 for an invention which is within two years of moving out of MIT into a commercial entity. Grants are for one year and can be renewed over multiple years, for a cumulative maximum of $250,000. The Center's Catalyst Program involves volunteer mentors from the external I&E community, who provide mentoring to grantees. Since its inception, the Center has supported the work of 300 faculty, graduate students and post-doctoral researchers, and funded more than 125 projects with grants totaling more than $15 million. Thirty-two companies have spun out of the Center and have collectively raised over $600 million in capital. Nearly 30 percent of funded projects spin out a new enterprise.

Addressing Industry Problems through Entrepreneurial-Laboratory Partnerships: Fraunhofer's TechBridge -- A U.S.-based international example - the Fraunhofer Center for Sustainable Energy Systems (CSE) - in 2010 created TechBridge, a commercialization arm for CSE. TechBridge performs as an applied R&D contract research organization. It actively seeks to identify problems in major industries that can be solved through CSE, and by identifying and working with startups that can bring their expertise to add R&D value that of CSE. It identifies startups to address specific technological problems through its extensive network with local universities and Boston's active I&E community. If the work generates IP specific to the project, then CSE will own the IP. Depending upon the project, they will sometimes provide a non-exclusive, royalty-free option to the startup. TechBridge does not invest funding in the startups that it works with and does not normally take an equity position, but does assist them in linking to potential investors and corporate partners. Since 2008, Fraunhofer CSE has filed and licensed several patents in photovoltaic and building energy technologies and has supported over 30 early-stage cleantech companies that have raised more than $67 million in follow-on funding.

Recommendations and Next Steps

In this executive summary, we briefly reviewed some barriers to national laboratory partnerships and described exemplary programs that employ creative solutions to advance private sector partnerships and commercialization. Some of the highlighted programs are new and evolving, and we encourage other national laboratories to use these programs as a base, building on them and taking them to the next level as well as experimenting with their own unique programs.

Two of the models highlighted here are particularly promising: Berkeley Lab's Cyclotron Road and CalCharge. Cyclotron Road combines the strengths of external innovators and the resources and expertise of national laboratories. Managing the program through a national laboratory-affiliated organization or other organization(s) rather than directly through the laboratory as it is now managed, might enhance the program by making it more attractive to external innovators. Such an arrangement could potentially offer more flexible and favorable terms. In addition, the Cyclotron Road program could be enhanced further by adding a second phase - Cyclotron Road "Plus-up" - that would provide follow-on matching funding for those innovators successful in attracting investment capital for commercialization. The program also would benefit from the laboratory or affiliated organization(s) proactively connecting innovators to the Lab-Corps program, showcasing related innovations, and pro-actively connecting them with investors and potential customers. It is our understanding that, in the near future, Cyclotron Road will enhance their program with external connections in this way. CalCharge, another promising model, leverages its nonprofit organizational status by employing a Master Services Agreement or umbrella CRADA to facilitate private sector and other partnerships with Berkeley Lab. This model could be expanded in several ways. The potential value-adds could include (a) creating inter-disciplinary R&D teams involving multiple corporations, academic institutions and national laboratories to address specific industry problems; (b) adding a highly focused laboratory that is designed to accelerate specific types of technologies spinning out of Berkeley Laboratory; (c) providing industry portal services for the full range of national laboratory R&D; and (d) creating an evergreen fund that would invest in potential spinouts.

NMC also provides a good base upon which laboratories can build. Small, specialized laboratories that operate outside of the national laboratory's fence, such as NMC's Biological Laboratory, allow the national laboratory to explore related R&D that may be of interest to the private sector and philanthropic institutions but are too risky, tangential or for security reasons cannot be performed at the national laboratory. In addition, by creatively applying an academic standing status for national laboratory researchers working on specific NMC projects, the Consortium has expanded LANL's R&D reach. ORNL's MDF provides another good model for laboratories to replicate. MDF has implemented some promising pilots involving university and private sector researchers, and has shown impressive results from its industry collaborations. MDF and similar user facilities might consider adding further value through processes similar to those used by Germany's Fraunhofer centers and its U.S.-based programs such as TechBridge. These programs proactively identify industry problems and address them by applying the combined resources and expertise of universities, national laboratories and entrepreneurs.

National laboratories could replicate some university acceleration models covered in this report, such as MIT's Deshpande Center, by applying maturation funding and external mentoring to commercialize promising innovations. Other state and local technology and acceleration programs not covered here, such as those found in Pittsburgh, New York and Kentucky, and private sector models also should be further explored for potential adaptation to national laboratories. Where possible, linkages between national laboratories and these programs should be made.

There are additional activities not covered here that might enhance national laboratories' private sector partnering and R&D commercialization efforts. Under recent reauthorizations, national laboratories are allowed to participate in the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs. By proactively identifying potential R&D and SBIR/STTR partners, laboratories can participate in a no-cost (to the laboratories) avenue for development and commercialization, combining their R&D with that of external businesses and universities. Participation of national laboratories in NMIIs, exemplified by MDF's leadership in IACMI and participation in America Makes, also benefits the laboratories through increased private sector and university collaborations. The NMII collaborations potentially provide a vehicle for acceleration and diffusion of national laboratory innovations. In addition, engaging national laboratories with the Manufacturing Extension Partnership (MEP) could provide a mechanism for linking evolving national laboratory technologies to small- and medium-sized manufacturers. At the writing of this report, it is our understanding that greater MEP and national laboratory connections are being explored.

Organizing industry advisory boards is one of the most valuable and least costly activities that a national laboratory can do. These advisory boards provide the laboratory with insights on and connections to private sector R&D, and the potential for collaboration and technology transfer. The boards should involve a wide range of private sector representatives including investors, entrepreneurs and manufacturers as well as major corporations. National laboratories should organize these boards at the director's level and at each key center/division. Additionally, mapping of R&D in specific fields could help identify strategic R&D direction for national laboratories and potential partnership opportunities.

Perhaps the most important aspect to improving private sector partnerships, technology transfer and commercialization are the cultural changes in national laboratories that need to take place. To this end, national laboratory and DOE leadership should review researchers' incentives and rewards regarding private sector partnering and commercializing R&D. Universities provide some good examples including allowing faculty to devote a portion of their time to perform external consulting, giving credit toward promotion, providing awards, using hiring practices that favor some corporate experience, providing entrepreneurial education, and facilitating opportunities for external networking. In terms of commercialization and entrepreneurial training, Lab-Corps is a good start, and more could be done in this area. A Lab-Corps "Phase II" might competitively select particularly promising Lab-Corps "graduates" for follow-on acceleration and commercialization funding and external mentoring.

In order for national laboratories to truly enhance their partnerships and potential for technology transfer and commercialization, DOE policies and practices must be addressed. In this report, we cite numerous issues that range from excessive centralization to presumption of unacceptable risk in determining licensing agreements. As we have noted, EERE has attempted to address some of the barriers by implementing several pilots. However, many barriers remain. Greater flexibility by DOE, allowing individual laboratories to experiment with their own programs and practices is critical to finding ways to advance private sector partnerships and technology transfer. Additionally, a small increase in the percentage of laboratory funding dedicated to industry partnering, technology transfer and commercialization would go a long way in advancing partnering and commercialization goals. Ongoing evaluation and dialogue with the private sector aimed at making real change, and Congressional attention to addressing barriers is needed to fulfill intended Congressional mandates and Presidential Executive Orders.

Given the current DOE leadership and some dynamic national laboratory directors, there is a window of opportunity for DOE national laboratories to enhance partnerships, collaboration and commercialization. At the writing of this summary, Bill Gates and other philanthropists have announced major commitments in renewable energy. There has never been a more propitious time to experiment with new paradigms that leverage the nation's enormous national laboratory resources to create partnerships resulting in energy breakthroughs benefitting people nationally and globally, now and for generations to come.

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ACRONYMS AND ABBREVIATIONS

ACCESS	Argonne Collaborative Center for Energy Storage Science
ACT	Agreement for Commercializing Technology
AEIC	American Energy Innovation Council
AMO	Advanced Manufacturing Office (DOE/ORNL)
ARPA-E	Advanced Research Projects Agency-Energy
ASU	Arizona State University
AzTE	Arizona Technology Enterprises
BELLA	Berkeley Laboratory Laser Accelerator
Berkeley Lab	Lawrence Berkeley National Laboratory
CalCEF	California Clean Energy Fund
CAP	Center for American Progress
CESA	California Energy Storage Alliance
CFTF	Carbon Fiber Technology Facility (ORNL)
CIB	Clean Tech Innovation Bridge
CIE	Chicago Innovation Exchange
CIM	Chicago Innovation Mentors
CRADA	Cooperative Research and Development Agreement
CFTF	Carbon Fiber Technology Facility (ORNL)
CSE	Center for Sustainable Energy Systems (FhG USA)
DOE	(U.S.) Department of Energy
DESI	Dark Energy Spectroscopic Instrument
EERE	Energy Efficiency & Renewable Energy (Office) (DOE)
EIR	Entrepreneur-in-residence
EFRC	Energy Frontier Research Centers
ENSI	Energy Nanoscience Institute (Berkeley Lab)
FhG	Fraunhofer Gesellschaft
FFRDC	Federally Funded Research and Development Center
GAO	(U.S.) Government Accountability Office
IA	Innovation Associates
I&E	Innovation and entrepreneurship
IACMI	Institute for Advanced Composites Manufacturing Innovation
ILP	Industrial Liaison Program (MIT)
ILO	Industrial Liaison Officer
IN2	Innovation Incubator (NREL)
ITIF	Information Technology and Innovation Foundation
JCESR	Joint Center for Energy Storage Research

LANL	Los Alamos National Laboratory
LDRD	Laboratory Directed Research and Development
LLNL	Lawrence Livermore National Laboratory
ORNL	Oak Ridge National Laboratory
OS	Office of Science (DOE)
OSI	Office of Strategy and Innovation (Argonne)
OTT	Office of Technology Transfer
M&O	Management and operations
MDF	Manufacturing Demonstration Facility (ORNL)
MIT	Massachusetts Institute of Technology
MOU	Memorandum-of-understanding
NIST	National Institute of Standards and Technology
NMC	New Mexico Consortium
NMII	National Manufacturing Innovation Institute
NREL	National Renewable Energy Laboratory
NSEC	National Security Education Center (LANL)
NTRC	National Transportation Research Center (ORNL)
OKED	Office of Knowledge Enterprise Development (ASU)
PNNL	Pacific Northwest National Laboratory
R&D	Research and development
RAMP-UP	Research for Additive Manufacturing Program - University Partnerships
SBIR	Small Business Innovation Research
SEAB	Secretary of Energy Advisory Board
SLAC	SLAC National Accelerator Laboratory (Stanford University)
SME	Small- and medium-sized enterprises
SNL	Sandia National Laboratory
SPP	Strategic Partnership Projects
STPI	Science and Technology Policy Institute (Institute for Defense Analysis)
STTR	Small Business Technology Transfer
TRL	Technology Readiness Level
TVC	Technology Ventures Corporation
UC	University of California
UChicago	University of Chicago
UT	University of Tennessee
WFO	Work for Others

INTRODUCTION

National laboratories have been the driving force behind many of the scientific and technological innovations that Americans now take for granted. Since their inception in the 1940's, the national laboratories have led to many of the country's research and development (R&D) breakthroughs in energy, security, computing, materials, transportation, cancer treatment, and numerous other areas. As the laboratories have evolved, the R&D that they perform has grown increasingly complex and inter-disciplinary, requiring new models of cooperation and collaboration with academia and industry. Through partnerships with the private sector, laboratories are able to move their innovations to market, ultimately benefitting the public nationally and globally.

Argonne National Laboratory (Argonne) is one of the nation's leading U.S. Department of Energy (DOE) national laboratories. It conducts a wide range of R&D in clean energy, environment, technology and national security, including batteries, fuel-efficient technologies, nano-scale materials, advanced computing and many other science and engineering areas that aim at breakthroughs and expand the frontiers of knowledge. Argonne's vision is to pursue groundbreaking discoveries that redefine and transform scientific and engineering R&D into innovations that will have profound, beneficial societal impacts. To that end, Argonne's Director, Peter Littlewood intends to expand Argonne's partnerships with the private sector, other institutions and agencies, and identify new ways by which Argonne's innovations can be more rapidly transferred to the commercial marketplace.

As part of the Argonne Director's vision, Innovation Associates, Inc. (IA) of Reston, VA was contracted to identify and assess some of the nation's exemplary programs and practices in national laboratory-industry partnerships, technology transfer and commercialization that might be applied to enhance those programs and practices at national laboratories. IA focused its work on national laboratory exemplars, and additionally included some university and other models. IA's work was intended to address the following questions:

- What innovative organizational structures, programs and practices implemented by national laboratories, universities, and other institutions are effective in enhancing private sector partnerships and commercialization?
- How can national laboratories most effectively lower their liability risk from private sector partnerships while leveraging these partnerships to accelerate commercial output?

- ❖ How can national laboratories better engage small- and medium-size enterprises (SMEs), particularly mid-size firms?
- ❖ How can a laboratory promote an entrepreneurial culture within the laboratory while maintaining the integrity of its research?
- ❖ How can laboratories better leverage their R&D through regional, national and international collaboration, and contribute to the regional innovation and entrepreneurial ecosystem?

IA, in conjunction with Argonne's Office of Strategy and Innovation (OSI), selected exemplary organizations and practices. Of particular interest were national laboratory-affiliated organizations that served as intermediary vehicles, facilitating industry partnering, technology transfer and commercialization between the private sector and the national laboratory. IA also examined programs and practices that could be incorporated in either an affiliated external organization or within a national laboratory's existing structure. IA conducted site visits and telephone interviews with directors of the selected organizations and programs from May to October 2015. IA also met with directors and staff at DOE headquarters from the Office of Science (OS), Energy Efficiency and Renewable Energy (EERE), EERE's Advanced Manufacturing Office (AMO), Advanced Research Projects Agency-Energy (ARPA-E) and Office of Technology Transitions (OTT). Other interviews and meetings with Argonne's M&O contractor, the University of Chicago, Argonne division directors and staff, and Chicago regional institutions are not reflected in the nationally released report.

IA's original task to identify and assess four to five exemplars expanded to include additional exemplars that IA felt were important in showing the breadth of initiatives that might be applied to national laboratories. The exemplars selected are only some of those that could be adapted to national laboratories; others, particularly accelerators and private sector programs and practices, were not included due to scope limitations. The selected models do provide some of the most innovative programs and practices to facilitate national laboratory-industry partnering, technology transfer, commercialization, and in a few cases, entrepreneurship. Selected exemplars were (in alphabetic order):

- ❖ Arizona Technology Enterprises, affiliated with Arizona State University
- ❖ Berkeley Lab Foundation, affiliated with Lawrence Berkeley National Lab (Berkeley Lab)
- ❖ CalCharge, affiliated with Berkeley Lab
- ❖ Cyclotron Road, Berkeley Lab
- ❖ Deshpande Program, Massachusetts Institute of Technology (MIT)
- ❖ Fraunhofer USA Center for Sustainable Energy Systems and TechBridge
- ❖ Industrial Liaison Program, MIT

- Industry Growth Forum, National Renewable Energy Laboratory (NREL)
- Innovation Incubator, NREL
- Manufacturing Demonstration Facility (MDF), Oak Ridge National Laboratory (ORNL)
- New Mexico Consortium (NMC), affiliated with Los Alamos National Laboratory (LANL)
- Technology Ventures Corporation, affiliated with Sandia National Laboratory (SNL)

These exemplars are detailed and discussed in the body of this report.

STRUCTURE OF THE REPORT

Following this brief introduction, we discuss the DOE national laboratories' mandate for industry partnering, technology transfer and commercialization, and some of the barriers that impede these practices and outcomes. We then discuss potential mechanisms for promoting partnering and commercialization and the rationale for creating an external organization affiliated with a national laboratory. This is followed by "Developing Laboratory-Affiliated Organizations and Enhancing Laboratory Programs: Exemplary Models" which presents a detailed discussion and examples of laboratory-affiliated organizations and internal laboratory programs and initiatives. Lastly, we present some concluding comments in "Summary Remarks and Next Steps".

MANDATE TO PROMOTE TECHNOLOGY TRANSFER

Innovation is a key component of U.S. economic prosperity, and technology transfer and commercialization are key drivers of successful innovation. Both the executive and legislative branches of government have set policies supporting partnering of the national laboratories with industry to promote commercialization of innovative technologies. Congress has enacted a series of laws since 1980 that recognize the importance of technology transfer and commercialization, and has supported and encouraged collaborations between industry and the federal and national laboratories.[12] Among these, the Stevenson-Wydler Technology Innovation Act of 1980 declared the need for a "strong national policy supporting domestic technology transfer and utilization of the science and technology resources of the federal government."[13] More recently, the Energy Policy Act of 2005 established a technology-transfer

[12] Executive Office of the President, President's Council of Advisors on Science and Technology, *Report to the President, Transformation and Opportunity: The Future of the U.S. Research Enterprise*, (Washington, DC, November 2012), 49.
[13] Stevenson-Wydler Technology Innovation Act of 1980, 15 U.S.C. §3701 (1980).

coordinator to act as principal advisor to the Secretary of Energy, and a technology-transfer working group to coordinate such activities at the DOE national laboratories.[14]

The executive branch has likewise undertaken numerous efforts to promote technology transfer and commercialization. In an October 2011 Presidential Memorandum, President Obama set a goal of fostering innovation "by increasing the rate of technology transfer and the economic and societal impact from federal research and development (R&D) investments."[15] The Memorandum committed each executive department and agency involved in conducting research to improve commercialization and technology transfer results, with an aim to produce significant improvement over five years. Former DOE Secretary Steven Chu and current DOE Secretary Ernest Moniz have echoed this call to action. In 2011, then-Secretary Chu issued a Policy Statement to strengthen DOE's technology transfer efforts, noting that technology transfer provides "ongoing economic security and environmental benefits for all Americans."[16] In early 2015, DOE Secretary Moniz announced the launch of the Office of Technology Transitions to promote commercialization of DOE research, with a focus on the national laboratories.[17] During his 2013 nomination hearing, Secretary Moniz argued that the DOE could do more in the technology transfer arena, and felt that "there were other barriers that could be lowered," including working collaboratively with universities to create "more pull for the technology out of the laboratories."[18]

TECHNOLOGY TRANSFER AND COMMERCIALIZATION: BARRIERS AND OPPORTUNITIES

In spite of the efforts to promote technology transfer and commercialization at the national laboratories, significant barriers remain. A recent report produced jointly by the Information Technology and Innovation Foundation (ITIF), Center for American Progress (CAP) and the Heritage Foundation described the persistence of "a number of policy, budgeting, cultural, and

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[14] Federal Laboratory Consortium for Technology Transfer, "The Green Book: Federal Technology Transfer Legislation and Policy," 5th ed. (2013): xiv. http://www.federallabs.org/flc/store/greenbook/.

[15] White House Office of the Press Secretary, *Presidential Memorandum—Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Businesses*, U.S. Government Publishing Office, October 28, 2011, 1. http://www.gpo.gov/fdsys/pkg/DCPD-201100803/pdf/DCPD-201100803.pdf.

[16] US Department of Energy, *Secretarial Policy Statement on Technology Transfer at DOE facilities*, (Washington, DC, 2011), 1. http://energy.gov/sites/prod/files/gcprod/documents/Policy_Statement_on_TT.pdf.

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

[18] *Hearing to Consider the Nomination of Dr. Ernest Moniz to be the Secretary of Energy, Before the Committee on Energy and Natural Resources, United States Senate*, 113th Cong. 17 (2013) (statement of Ernest Moniz). 21. http://www.gpo.gov/fdsys/pkg/CHRG-113shrg80930/pdf/CHRG-113shrg80930.pdf.

institutional barriers to interacting with industry."[19] An interim report by the DOE Commission to Review the Effectiveness of the National Energy Laboratories found that support for technology transfer is "inconsistent across the laboratories and across the DOE program offices."[20] An expert panel at the White House Lab-to-Market Inter-Agency Summit noted that commercialization of discoveries from federal agency research "has largely been an after-thought."[21] Numerous reports on the state of technology transfer and commercialization at the national laboratories have identified a variety of cultural and policy-based barriers to greater cooperation with industry.

Brookings, DOE's Secretary of Energy Advisory Board (SEAB) National Laboratory Task Force, ITIF/CAP/Heritage Foundation, and others have identified a variety of cultural barriers that inhibit or impede DOE technology transfer and commercialization. Brookings noted that the national laboratories have "made neither technology commercialization nor regional cluster participation a top priority."[22] Brookings noted that the Commercialization Fund called for in the Energy Policy Act of 2005 has been poorly implemented by DOE, with DOE choosing to retroactively apply matching CRADA funds towards the funding requirement rather than designing a strategy for using the funding to promote commercialization.[23] This practice was described in a DOE audit by the Office of Inspector General as failing to provide the forward-looking approach Congress intended.[24]

The interim report by the SEAB Task Force found that the centralized approach taken by DOE headquarters towards technology transfer has resulted in inconsistent expectations for engagement with industry by the national laboratories, including a lack of clarity on whether technology transfer is even a legitimate laboratory objective.[25] Laboratory directors have described DOE headquarters' expectations regarding industry engagement as being "cyclical," exacerbating the uncertainty regarding the importance of technology transfer as an element of DOE's mission. This is compounded by national laboratory-evaluation metrics that do not place

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[19] Matthew Stepp, Sean Pool, Nick Loris, and Jack Spencer, Turning the Page: Reimagining the National Labs in the 21st Century Innovation Economy, (The Information Technology and Innovation Foundation, The Center for American Progress, The Heritage Foundation, June 2013), 42.
[20] *Interim Report of the Commission to Review the Effectiveness of the National Energy Laboratories*, (US Department of Energy: February 27, 2015), vi. http://energy.gov/labcommission/downloads/interim-report-commission-review-effectiveness-national-energy-laboratories.
[21] National Expert Panel, "Recommendations from the National Expert Panel," 2.
[22] Andes, Muro, and Stepp, "Going Local," 1.
[23] Ibid., 5.
[24] DOE Office of Inspector General, *Audit Report: Technology Transfer and Commercialization Efforts at the Department of Energy's National Laboratories*, (Washington: February 2014), 3.
[25] Secretary of Energy Advisory Board, *Report of the Secretary of Energy Task Force on DOE National Laboratories*, (US Department of Energy: June 17, 2015), 29, 26. http://www.energy.gov/seab/downloads/interim-report-task-force-doe-national-laboratories.

weight on technology transfer, and a lack of useful metrics to measure the extent of technology transfer and economic outcomes.[26]

Additionally, the ITIF report described conservative interpretations of conflict-of-interest laws by laboratory legal counsels as making it "difficult for researchers to form innovative partnerships, and creat[ing] the misconception that such partnerships are morally or ethically dubious."[27] This can severely restrict the creation of a culture of entrepreneurship among laboratory researchers, and disincentivize collaborations between those researchers and industry.

The SEAB Task Force found that DOE's centralized approach to promoting technology transfer at the national laboratories created barriers to policies intended to promote to technology transfer.[28] DOE's efforts to define uniform cooperation mechanisms with industry, as well as uniform approval and reporting requirements for all national laboratories, create process complexity and lack of flexibility in cost-sharing and intellectual property ownership that impede industry engagement.[29] This has also led to an extensive preapproval process from DOE for nearly all technology transfer agreements entered into by the national labs. ITIF also concluded that this process effectively makes all existing tools for laboratory-industry collaboration overly costly and time-intensive, especially for smaller companies.[30] In fact, the government-industry interaction process has become so complicated, "industry is largely unaware of opportunities to collaborate with the federal laboratories."[31] Brookings likewise argued that "micromanagement of investment decisions by DOE and Congress makes it incredibly difficult" for national laboratories to enter into research and outreach collaborations with local businesses and partners.[32] Brookings also argued that the additional bureaucracy and resulting complexity in contracting rules and timelines aligns especially poorly with "the needs of smaller firms."[33]

Those contractual relationships that do occur between the national laboratories and industry are developed through a variety of different mechanisms. The SAEB Task Force found that

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[26] Stepp, et al., *Turning the Page*, 48.
[27] Ibid., 47.
[28] Secretary of Energy Advisory Board, *Report on DOE National Laboratories*, 29.
[29] Ibid.
[30] Stepp, et al., *Turning the Page*, 46.
[31] Mary Elizabeth Hughes, Susannah Vale Howieson, Gina Walejko, Nayanee Gupta, Seth Jonas, Ashley T. Brenner, Dawn Holmes, Edward Shyu, and Stephanie Shipp, *Technology Transfer and Commercialization Landscape of the Federal Laboratories*, Institute for Defense Analyses Science & Technology Policy Institute (IDA Paper NS P-4728: June 2011), vi.
[32] Andes, Muro, and Stepp, "Going Local," 8.
[33] Ibid., 6.

these mechanisms are inflexible and impose a significant administrative burden on industry-laboratory collaboration. Most significantly, the Task Force attributed a general preference at national laboratories for Strategic Partnership Projects (SPPs) (formerly Work-for-Others) to Cooperative Research and Development Agreements (CRADAs) to be due to the higher administrative burden associated with CRADAs. The Task Force also noted that laboratories primarily pick one mechanism to use exclusively, and that this behavior "suggests that once a laboratory figures out the process for one mechanism, it uses that mechanism at the expense of others."[34] This conclusion aligns with concerns expressed in a 2009 U.S. Government Accountability Office (GAO) report finding that a "lack of flexibility" in negotiating technology transfer agreements was a primary challenge to expanding commercialization of laboratory technology.[35] The SEAB Task Force likewise found that the time required to negotiate and approve a project under existing contract mechanisms greatly restricts the number of opportunities available for collaboration.[36]

An additional policy-based concern relates to weak incentives created for national laboratory managers and staff to work with industry. Laboratory managers are not able to capture the true value of their innovation or other asset due to limitations on funds generated through cooperation with industry, as they are frequently only allowed to charge pre-determined fees for services, leaving them unable to charge market rates.[37] This limits potential benefits to taxpayers, but also limits the incentive to laboratory managers to engage with industry. Brookings has likewise called for permitting national laboratories to "engage in non-federal state and regional funding partnerships" that do not require DOE approval.[38] The SEAB Task Force expressed that providing laboratory managers with the discretion to seek non-federal funding partnerships will allow greater engagement with regional partners, while permitting more flexible funding.

Incentives for individual personnel to participate in entrepreneurial ventures are also limited, thereby disincentivizing participation in industry collaboration at the individual level.[39] A recent Institute for Defense Analysis' Science and Technology Policy Institute (STPI) report found that laboratory researchers "may lack the knowledge, ability, and incentives necessary" to undertake the research and business activities necessary to promote technology transfer and

[34] Secretary of Energy Advisory Board, *Report on DOE National Laboratories*, 27.
[35] Government Accountability Office, "Technology Transfer: Clearer Priorities and Greater Use of Innovative Approaches Could Increase the Effectiveness of Technology Transfer at Department of Energy Laboratories" (2009), available at http://www.gao.gov/assets/300/290963.pdf.
[36] Secretary of Energy Advisory Board, *Report on DOE National Laboratories*, 29.
[37] Stepp, et al., *Turning the Page*, 42-43.
[38] Andes, Muro, and Stepp, "Going Local," 11.
[39] Secretary of Energy Advisory Board, *Report on DOE National Laboratories*, 27.

commercialization.[40] Researchers at national laboratories are also more restricted than researchers at universities in the types of activities they can engage in with industry. University researchers receive more flexibility with regard to beginning startups or taking equity, and they are permitted greater leeway with regard to outside consulting.[41] Additional opportunities include the ability to consult one day per week and obtain outside funding for their programs.[42] This greater flexibility promotes a culture of entrepreneurship and facilitates a closer relationship between university researchers and industry than between national laboratory researchers and industry.

More recently, DOE has been willing to experiment with alternative structures and mechanisms to ameliorate some of these barriers to technology transfer. Agreements for Commercializing Technology (ACT), an alternative technology transfer mechanism, were created as a pilot program in 2012 to give national laboratories a more flexible platform to negotiate with research partners. ACTs provide more flexible partnership terms, including permitting multiparty partnerships and performance guarantees, speeding the formation of agreements, and enhancing intellectual property flexibility.[43] However, ACT agreements are limited to research partners that do not receive federal funding, limiting its potential impact.[44] For many companies, including those that would typically want to partner with the national laboratories, existing mechanisms for partnerships still remain overly costly and time intensive.

DOE has also attempted to find alternative opportunities to promote commercialization of laboratory technologies. These efforts include its Lab-Corps pilot program, providing market feedback to lab-based teams that promote development of startup companies and other commercialization mechanisms such as licensing, CRADAs, and SPPs. DOE has also worked to make national laboratories' unlicensed patents available to startups through its Next Top Energy Innovator Program, and made available patents searchable through its Online Energy Portal.[45] In December 2013, DOE EERE launched the Laboratory Impact Initiative, whose goals include enhancing laboratory-private sector relationships and streamlining partners' access to national laboratory capabilities.[46] Additionally, the American Energy Innovation Council (AEIC)

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40 Hughes, et al. *Technology Transfer and Commercialization Landscape*, 26.
41 Ibid., 29.
42 Ibid.
43 Howieson, Susannah, Brian J. Sergi, and Stephanie S. Shipp. "Department of Energy Agreements for Commercializing Technology," IDA Science & Technology Policy Institute, April 2013, available at: https://www.ida.org/~/media/Corporate/Files/Publications/STPIPubs/ida-p-5006.ashx.
44 Stepp, et al., *Turning the Page*, 46.
45 "From Lab to Market: DOE's America's Next Top Energy Innovator Program," US Department of Energy, April 5, 2013, http://energy.gov/articles/lab-market-does-america-s-next-top-energy-innovator-program.
46 "About the National Laboratory Impact Initiative," US Department of Energy, accessed September 10, 2015, http://energy.gov/eere/lab-impact/about-national-laboratory-impact-initiative.

credited DOE's creation of Energy Innovation Hubs, such as the JCESR and the Critical Materials Institute, with investing in "basic research linked to initial product development" and bringing together personnel of DOE national labs, universities, and industry.[47] The AEIC report also credited Energy Frontier Research Centers (EFRCs) with driving collaboration between university, industry, non-profit, and national laboratory researchers.[48] DOE credits these collaborations with producing 5,400 peer-reviewed scientific publications, "hundreds of inventions at various stages of the patent process," and benefitting both large and small firms.[49] Finally, National Manufacturing Innovation Institutes (NMIIs), joint projects between DOE, the Department of Commerce, and Department of Defense, bring together national laboratories, universities, and companies to accelerate development and commercialization of manufacturing technologies.[50] These initiatives have been credited with significant private-sector contributions, in some cases receiving more from the private sector than in government funding.[51]

A variety of additional mechanisms and policy changes could promote national laboratory interactions with industry even further. External mechanisms involving the creation of intermediary organizations have seen some success. The SEAB Task Force noted that some laboratory directors have already begun to seek new external mechanisms to interact with industry.[52] They refer to current experiments that support entrepreneurial and commercialization efforts based on laboratory-created technologies, including Berkeley Lab's Cyclotron Road program, and Berkeley Lab's work with CalCharge. Other experiments include co-location space to support collaborative research such as the "Livermore Valley Open Campus" collaboration between SNL-California and Lawrence Livermore National Laboratory (LLNL).[53] The NMC, affiliated with the LANL and three New Mexico universities also is an attempt to open the laboratory to greater external collaborations.

However, more needs to be done. The recent willingness of DOE EERE to experiment with various pilots, and the courageous experiments of Berkeley Lab and others, is encouraging. In

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[47] American Energy Innovation Council, *Restoring American Energy Innovation Leadership: Report Card, Challenges, & Opportunities*, (Bipartisan Policy Center: February 2015), 9.
[48] Ibid.
[49] "DOE Awards $100 Million for Innovative Energy Research," US Department of Energy, June 18, 2014, http://energy.gov/articles/doe-awards-100-million-innovative-energy-research.
[50] American Energy Innovation Council, *Restoring American Energy Innovation Leadership*, 9.
[51] Mark Muro and Scott Andes, "Kludging Out Progress: The Case of Manufacturing Hubs," The Brookings Institution, March 6, 2014, http://www.brookings.edu/blogs/the-avenue/posts/2014/03/06-manufacturing-hubs-muro-andes.
[52] Secretary of Energy Advisory Board, *Report on DOE National Laboratories*, 28.
[53] "Livermore Valley Open Campus: Fostering Collaborative Sollutions to Tough Problems," Lawrence Livermore National Laboratory, accessed September 27, 2015, https://www.llnl.gov/sites/default/files/lvoc_fact_sheet_0.pdf.

the following discussions, we discuss how national laboratories can leverage and apply some of the good work that has been started by others, and add value to that work.

RATIONALE FOR CREATING AN EXTERNAL ORGANIZATION

In the previous section, we outlined some of the obstacles to industry partnerships, technology transfer and commercialization. We noted that while DOE, particularly EERE, has created a number of initiatives to address some barriers to industry partnerships and technology transfer, that national laboratories remain risk averse, narrowly focused, and difficult for private sector firms, particularly small- and medium-sized enterprises (SMEs), to work with. One of the options to address these issues is to create an external, nonprofit organization that is located "outside the laboratory's fence", acting as an intermediary that links the private sector to the laboratory and performing functions that add value and bring the laboratory's R&D closer to market. Ideally, the nonprofit organization also would positively impact the laboratory's R&D and culture internally by enhancing its knowledge of and contact with the private sector.

External organizations offer one way in which national laboratories can more effectively

- Reduce risk;
- Increase flexibility and speed to market;
- Pursue and leverage broader research interests;
- Connect with the region's innovation and entrepreneurial ecosystem; and
- Add value to the lab's internal R&D and innovation culture.

There are several national laboratories, including Berkeley Lab and LANL that have developed external nonprofit organizations that remain closely affiliated with the laboratory. Throughout this section, we refer to these and other national laboratory examples, and additionally reference some university and other institutional examples.

REDUCING RISK

Many universities have created nonprofit organizations in order to provide greater indemnification and more flexibility regarding technology transfer and other private sector interactions. State institutions particularly have taken this route due to concerns from state legislatures about the liability that might arise from external engagements. Some examples of these university-affiliated organizations are:

- Wisconsin Alumni Research Foundation, affiliated with the University of Wisconsin;
- Arizona Technology Enterprises (AzTE) and Arizona State University (ASU) Foundation, affiliated with ASU;

- Georgia Tech Research Corporation, affiliated with Georgia Tech;
- Purdue Research Foundation, affiliated with Purdue University;
- University of Akron (UA) Research Foundation, affiliated with University of Akron.

National laboratories have similar concerns to state universities regarding indemnification. As universities have developed external organizations to provide an "arm's length" distance to reduce liability, national laboratories too have begun to experiment with creating nonprofit organizations for some of the same reasons as universities. Examples include (but are not limited to):

- CalCharge, affiliated with Berkeley Lab;
- Berkeley Lab Foundation, affiliated with Berkeley Lab;
- NMC, affiliated with LANL;
- Technology Venture Corporations (TVC), affiliated with SNL; and
- Sandia Science and Technology Park, affiliated with SNL.

Where a nonprofit organization has been established to act as an intermediary between the private sector and the national laboratory or university, there is greater indemnification for the laboratory or university.

INCREASING FLEXIBILITY AND SPEED TO MARKET

Nonprofit organizations are less encumbered than national laboratories in many ways that make them more flexible in working with the private sector. This increased flexibility involves (but is not limited to):

- Regulatory issues;
- Funding of research projects and use of funds;
- Hiring practices; and
- Physical access to laboratories.

Regulatory Issues

In addition to indemnification issues, there are a number of regulatory concerns that tend to reduce the laboratories' flexibility in their dealings with the private sector. Some of these concerns include (but are not limited to):

- National laboratories must perform R&D for the public good;

- ❖ National laboratories cannot compete with the private sector;
- ❖ The laboratory must insure fairness of opportunity;
- ❖ Corporations entering into CRADAs must insure that they will make every effort when manufacturing laboratory related inventions, to use U.S. manufacturers.

While many of these requirements stem from Congressional mandates, they tend to restrict the laboratories' flexibility and increase the time needed to execute private sector agreements. While external organizations entering into agreements with national laboratories also must adhere to the same requirements, they are not bound by quite the same stringent interpretations. Representatives from CalCharge and the NMC claim that their organizations have reduced by several months the time needed for establishing private sector and federal agency (non-DOE) agreements with Berkeley Lab and LANL respectively.[54]

Funding of Research Projects and Use of Funds

One of the common complaints from corporations entering into CRADAs and SPPs concerns the national laboratories' high overhead rates. Moreover, most philanthropic foundations that may want to fund laboratory R&D or enter into other laboratory partnerships will not cover overhead or have very low caps. Foundation funding to national laboratories can become particularly complex. Philanthropic contributions to SLAC National Accelerator Laboratory (SLAC), for example, have been exclusively for off-site infrastructure and equipment. Other contributions such as those to Berkeley Lab have been channeled through a separate nonprofit organization, the Berkeley Lab Foundation and/or contributed directly to UC Berkeley[55] for use in joint UC-Berkeley Lab laboratories. (We discuss philanthropic funding in greater detail later in this section.)

In addition, a nonprofit organization is free to apply for federal grants that otherwise would not be available to a national laboratory or would be more problematic for it. For example, in the case of ORNL's MDF, a separate nonprofit organization was established by ORNL's M&O contractor, in order for MDF to enter into a federal application for the now funded Institute for Advanced Composites Manufacturing Innovation (one of the NMIIs). Forming a separate nonprofit organization enabled MDF to take a leadership position in the federal application.

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[54] Based on interviews with Jeff Anderson, CEO of CalCharge and Alan Hurd, Director of NMC.
[55] University of California is Berkeley Lab's M&O contractor.

Hiring and Compensation Practices

Hiring practices can be more flexible at a nonprofit organization where greater emphasis can be placed on entrepreneurship and corporate experience, and where the organization is not restricted to the M&O contractor's payment guidelines and structures. Organizations also can structure nontraditional forms of compensation such as offering equity positions in startups that may not be possible otherwise.

The employment of post-doc students in national laboratories can add value to the research but also can create concerns among partners who are mindful of proprietary information and who do not want students to publish research results. Nonprofit organizations may be able to more easily restrict publishing in order to accommodate partners who are concerned about proprietary information.

Physical Access to Laboratories

National laboratories to a greater or lesser extent have national security concerns. These security issues restrict the type of employee, particularly foreign students and non-U.S. citizen scientists and engineers, who can work in a secure laboratory site. For this reason, a number of national laboratories now have established some office facilities off-site. An external organization facilitates ease of private sector partnering on non-security sensitive R&D and unrelated functions.

PURSUING BROADER RESEARCH INTERESTS

While a national laboratory is confined to its core mission, an external organization has greater freedom to consider the "bigger picture", and the flexibility to act on it. An external organization is free to pursue broader research interests that go well beyond the mandate of an individual national laboratory, and more easily combine and leverage the R&D resources of other national labs, universities, private research institutes and industries.

The ability to draw upon and coordinate R&D from numerous research institutions is particularly important in addressing the increasing complexity and inter-disciplinary nature of today's research projects. A flexible organization is even more important for a national laboratory that is funded by DOE's OS where research is further away from market application than in DOE EERE and other laboratories and institutions. The ability to combine the strengths of more applied R&D institutions can add value to the basic science platforms of OS-funded labs, potentially bringing that research closer to market.

In the case of Berkeley Lab's affiliated CalCharge, the organization already involves three laboratories - Berkeley Lab, SLAC and LLNL, two universities - San Jose State University and UC San Diego, as well as its industry members. CalCharge intends to partner with additional national laboratories, universities, industries, public sector, and industry associations, giving it the ability to increase its research "bandwidth" by leveraging multiple institutional strengths.

CONNECTING WITH THE REGION'S INNOVATION AND ENTREPRENEURIAL ECOSYSTEM

The ability to interact and collaborate with the larger innovation and entrepreneurial (I&E) ecosystem is important to optimizing the commercialization of national laboratory R&D. A regional I&E ecosystem offers a variety of resources and services that extend the laboratory's capacity to support and nurture private sector commercialization of the laboratory's R&D, particularly by SMEs, entrepreneurs, and small manufacturers. An independent, nonprofit organization has greater flexibility to take advantage of its surrounding ecosystem and connect to an ecosystem that leverages and supports multi-sector coordination and collaboration. While a number of national laboratories' offices of economic development, strategic partnerships or technology transfer, such as that at Argonne, do reach out to the larger I&E community, the national laboratory culture often is not sufficient to promote substantial pro-active outreach and interaction with the external ecosystem. Moreover, non-profit organizations have the flexibility to interact, collaborate and form agreements with external organizations in a more expedient, seamless manner.

ADDING VALUE TO LABORATORY R&D AND CULTURE

Creating an organization that facilitates better industrial partnerships with a national laboratory, particularly one focused on translating and applying the laboratory's R&D, ultimately adds value to that research. It does so through increased interaction with industry that organically provides input on problem solving and industrial application. Moreover, an external organization that increases private sector interaction with the laboratory may create improved conditions for culture change within the laboratory. According to Venkat Srinivasan, Staff Scientist at Berkeley Lab, one of the early byproducts from CalCharge was a culture change within the Laboratory. He believes that CalCharge has encouraged additional innovative experimentation and prompted more entrepreneurial thinking.

DEVELOPING LABORATORY-AFFILIATED ORGANIZATIONS AND ENHANCING LABORATORY PROGRAMS: EXEMPLARY MODELS

In the previous section, we discussed the potential advantage to a national laboratory of having an affiliated nonprofit organization. In this section, we discuss exemplary models that will help define the organization's structure, management, operations and linkages. These models are intended to address the following questions:

- What are the steps that lead up to the establishment of a laboratory-affiliated organization?
- How should the organization be structured and managed?
- How much funding is required to start and sustain operations, and what are the potential funding sources?
- What key functions and services should the organization perform to promote national laboratory-industry partnerships, technology transfer and commercialization?
- How should the organization be aligned with a national laboratory and how can it best add value to the laboratory's mission?
- What should be the relationship with the national laboratory's M&O contractor?
- What linkages should the organization form with other organizations and resources in the region?
- What should be the organization's connection to other national laboratories and universities?
- What outcomes can be expected?

PREPARATORY STEPS

We provide two examples of early-stage organizational development from CalCharge and the Berkeley Lab Foundation, separately incorporated organizations that are affiliated with Berkeley Lab. The steps leading up to the creation of the nonprofit organization CalCharge and early stages of other organizations such as Berkeley Lab Foundation included substantial input from the Laboratory's directors and key staff, and the private sector. This input was important not only in prioritizing the R&D focus and determining the key functions, but also in insuring buy-in from Laboratory leaders and the private sector, some of whom became members of the future nonprofit organization.

CalCharge's startup was very much the result of Venkat Srinivasan, Staff Scientist in the Energy Storage and Distributed Resources Division at Berkeley Lab, who had taken a leave of absence to work in the private sector. His experiences in the private sector provided insight from experiencing the national laboratory-industry partnerships "from the other side", which influenced his thinking about the need for a mechanism and an organizational structure that would simply and expedite CRADAs. His experience and persistence in combination with the funding and support from CalCEF (formerly the California Clean Energy Fund) led to the creation of CalCharge. From 2011-2013, Berkeley Lab and CalCEF (formerly the California Clean Energy Fund) conducted due diligence to gain a deeper understanding of the state of the energy storage sector in California, its existing ecosystem, and any gaps and unfulfilled needs impairing its continued growth. To support this effort, CalCEF engaged Janice Lin of the California Energy Storage Alliance (CESA) as an entrepreneur-in-residence (EIR). Together they held several stakeholder meetings, which attracted a total of more than 200 industry, policy, and research leaders. CalCEF underwrote the costs associated with the meetings and, underwrote most of the development of CalCharge. Some of the issues identified at the stakeholder meetings were:

- The California cluster was highly fragmented with no institutionalized framework in place for collaboration, information sharing, and efficient resource allocation
- Large scale corporate and government end users that create and drive markets had few connections to emerging innovative technology developers, which limited opportunities for actual demand to drive innovation.
- Emerging companies had limited access to expertise, development facilities, and high-end scientific resources that are critical to their technology development process.
- There were critical gaps in workforce education, training, and certification programs.
- Research and development centers were generally not located near early-stage manufacturing facilities and their supply chains, which is increasingly essential for successful commercialization of new products.
- The pathway from "innovation to installation" was often slowed by a lack of insight and ability to influence construction, planning, transportation and other regulations that impact the ability to deploy new products.[56]

While many of these issues were general in nature, they highlighted the need for an organization that could serve as a focal point to enhance innovation in the region and to better connect the private sector, particularly emerging companies, to the scientific resources at the national laboratory and elsewhere. The stakeholder input and focus group recommendations helped to justify the need for a laboratory-affiliated organization and helped to secure funding from public sources. The recommendations also helped define the key functions for the organization.

[56] Source: CalCharge.

In the case of the Berkeley Lab Foundation, UC's first step in starting up the Foundation was to recruit its President, a highly successful Chief Development Officer, Ivy Clift, from Stanford University. Early in the development of the Berkeley Lab Foundation, Ms. Clift worked closely with the Berkeley Lab Director and discussed research priorities with Berkeley Lab's division directors. Based on these discussions, she developed a priority list that was presented to Berkeley Lab's Director, who had the ultimate say on the research priorities that would be pursued with charitable foundations. The Foundation President conveyed that early "buy in" from the Lab's management was a necessary and important step in the Foundation's development. Once the Lab's priorities were known, the next steps were to determine what R&D priorities and laboratory programs resonated with potential donors. (We discuss developing relationships with foundation donors later in this section.) Ms. Clift's recommendations to others developing an organization that involves philanthropic funding of R&D is to engage stakeholders: "networking is key to building a successful organization - it's all about the relationships".

LEGAL STRUCTURE

An organization that is affiliated with a national laboratory can be legally structured in a number of ways. We discuss some considerations here that are intended to help frame questions that should be addressed by qualified legal counsel.

One of the considerations in incorporating a laboratory-affiliated organization is to limit the liability to the national laboratory and the laboratory's M&O contractor. Nonprofit corporations such as a 501(c)(3) have the same liability protection as LLCs; that is, their directors, trustees, members and employees are not generally responsible for corporate debts and liabilities. A 501(c)(3) nonprofit corporation is exempt from payment of federal income tax for scientific and educational organizations such as an organization that conducts scientific research for the "public benefit". An important benefit to forming a 501(c)(3) nonprofit corporation is that it can receive grants from federal government agencies and private foundations. However, in order for a nonprofit corporation to maintain its nonprofit status, it must not distribute any profits for the benefit of directors, officers or members, and the board generally should be independent and financially disinterested. Therefore, if a laboratory-affiliated organization wishes to take an equity position in its spinoffs or corporate members, it may not necessarily meet the legal requirement for a nonprofit corporate status.

Another consideration is whether an affiliated organization intends to engage in "lobbying" in which case it would not qualify for a 501(c)(3) and might instead incorporate as a 501(c)(4) or 501(c)(6) nonprofit corporation. While this type of incorporation provides greater flexibility with regard to advocating for public issues, it also limits the organization's federal tax exemptions, and may affect the ability of the organization to receive federal government grants and private foundation contributions.

Some organizations that are affiliated with national laboratories are incorporated as follows:

- **CalCharge** -- is a LLC that is a wholly owned, for-profit subsidiary of CalCEF Catalyst, a 501(c)(6) non-profit corporation. (CalCEF also operates two related organizations: CalCEF Innovations, a 501(c)(3), and CalCEF Ventures, a 501(c)(4).)
- **NMC** -- is a 501(c)(3) nonprofit corporation affiliated with LANL.
- **Sandia Center for Collaboration and Commercialization** -- is part of the Sandia Science and Technology Park that is owned and managed by a 501(c)(3) non-profit corporation.
- **TVC** -- is a 501(c)(3) nonprofit charitable foundation established by SNL's M&O contractor, Lockheed Martin
- **Institute for Advanced Composites Manufacturing Innovation** (IACMI) -- a NMII affiliated with ORNL and the MDF; it is managed by a 501(c)(3) corporation established by the University of Tennessee (UT) Research Foundation for this purpose, which itself is a separate 501(c)(3) affiliated with UT.

It should be noted that representatives from several of the organizations listed here believe that their organization's legal structure is too complex. The recent former Director of CalCharge, Jeff Anderson, said that the lesson from the CalCharge development process could be leveraged to create a much more streamlined organizational structure for any future organization with a similar mission. This would likely result in the incorporation of a single 501(c)(3) non-profit organization that could also include another for-profit wholly owned LLC if needed to meet the "public benefit" test for the non-profit parent. Representatives of the IACMI and ORNL's MDF also commented that the legal structure established for MDF's leadership to participate in IACMI was more complex than would be ideal.

ORGANIZATION, MANAGEMENT AND FUNDING

There is a wide range of organizational models throughout the U.S. and internationally that could be applied to a national laboratory-affiliated organization. We provide examples here of organizations and also some internal practices that are affiliated with national laboratories and/or universities, mainly focusing on industry partnerships and technology transfer and commercialization, and to a lesser extent, some entrepreneurial tools. Most examples are separate, nonprofit organizations; others operate as units or programs in national laboratories or universities.

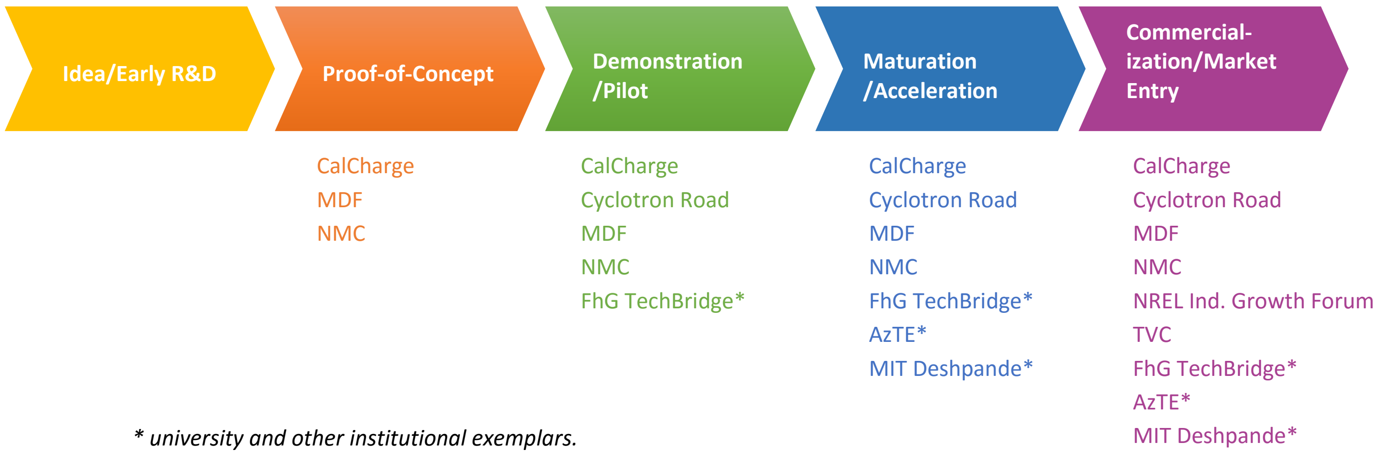
It is important to note that no one organization or practice "has everything". It is therefore best for a laboratory-affiliated organization to draw from a number of the models, targeting those components that best serve the laboratory's immediate goals, adding other components over time as the organization evolves, and augmenting the laboratory's organization with its own innovate experimentation that will serve as a model for others. While we have placed exemplary organizations and practices into specific categories, many do not fall neatly into a single category and many serve multiple purposes. It also is important to keep in mind the impact of the region's innovation and entrepreneurial ecosystem on the specific exemplar. We present here the organization, management and funding of model organizations and practices as follows:

- Enhancing industry partnerships and technology transfer:
    - CalCharge, affiliated with Berkeley Lab
    - ORNL MDF
    - MIT Industrial Liaison Program
    - AzTE, affiliated with ASU
    - Fraunhofer Center for Sustainable Energy Systems and TechBridge
- Attracting nontraditional funding:
    - NMC, affiliated with LANL
    - Berkeley Laboratory Foundation
- Accelerating innovations and promoting entrepreneurship
    - Cyclotron Road, Berkeley Lab
    - Innovation Incubator, NREL
    - Industry Growth Forum, NREL
    - TVC, affiliated with SNL
    - Deshpande Program, MIT

Figure 1 below shows an approximation of the lab-to-market stage in which the program operates.

Figure 1

National Laboratory Lab-to-Market: Exemplars



Enhancing Industry Partnerships and Technology Transfer

In previous sections, we have discussed the issues involved in developing national laboratory and private sector partnerships, and transferring and commercializing technologies. Here, we offer a variety of organizations and programs that in different ways facilitate industry R&D partnerships with institutions, and successfully promote commercialization. Berkeley Lab's nonprofit organization, CalCharge, provides an excellent example of a closely affiliated laboratory organization that acts as an intermediary, facilitating national laboratory-industry R&D through a membership structure and a Master Services Agreement or umbrella CRADA mechanism. ORNL's MDF is an internal laboratory user facility[57] that has developed innovative private sector partnerships, and has creatively linked with a nonprofit organization to provide leadership on an NMII. We also provide two university exemplars: MIT's Industrial Liaison Program, which is an internal program that acts as an industry portal to the institute's researchers, and AzTE, a nonprofit organization which performs ASU's technology transfer and commercialization. Lastly, we present a U.S.-based international example, a Fraunhofer Center that has created a new initiative, TechBridge; similar to a contract research organization, it facilitates commercialization of the Center's technologies.

Example: CalCharge and the CalCharge Master Service Agreement/CRADA: When a top researcher, Venkat Srinivasan, took entrepreneurial leave from Berkeley Lab to work in a private sector energy company, he returned to the Laboratory questioning why it was so

[57] At the writing of this report, MDF was not yet designated as an official DOE user facility.

difficult for the private sector to work with the national laboratories. Dr. Srinivasan and colleagues approached CalCEF to explore the possibilities of how Berkeley Lab might facilitate more productive, mutually beneficial relationships with the private sector. In 2012, Berkeley Lab and CalCEF partnered to create CalCharge as a public-private partnership intended to bring together California's battery technology companies with government and academic resources to accelerate the commercialization and market adoption of energy storage technologies, including electric and hybrid vehicles, the grid and consumer electronics markets. During this time, CalCEF also funded the head of CESA to work with Berkeley Lab as an EIR. We discussed some of the early stages involving multi-sector focus groups earlier in this section. We focus here on the funding, organization, master CRADA, and related functions.

CalCharge Organization and Management: CalCharge grew out of CalCEF, which was formed in 2004 with $30 million from the Pacific Gas & Electric bankruptcy settlement. CalCEF is an independent, non-profit public benefit corporation created to promote the development of institutional, public policy and investment vehicles to support the acceleration and adoption of clean energy technologies. CalCEF pursues these goals through three affiliated, separately incorporated entities: (a) CalCEF Ventures, a 501(c)(4) non-profit organization, which is CalCEF's investment arm that operates an evergreen investment fund; (b) CalCEF Innovations, a 501(c)(3) non-profit organization, which conducts analyses and product development; and (c) CalCEF Catalyst, a 501(c)(6) non-profit organization, which is an industry acceleration platform. Through Catalyst, CalCEF creates institutionalized frameworks for convening stakeholders across various sectors, targets issues and provides systems level strategies for its affiliated organizations (Innovation and Ventures), and develops programs and subsidiary organizations to accelerate innovations and address policy issues.

CalCharge is an LLC that is a wholly-owned, for-profit subsidiary of CalCEF Catalyst. There are minimally overlapping Boards with only one member sitting on two Boards and there is no leadership overlap on Boards. Berkeley Lab and SLAC also sit on the Board of the 501(c)(6), and Berkeley Lab additionally sits on the Board of the 501(c)(3). Our understanding is that placing CalCharge under CalCEF's 501(c)(3) was considered, but because of internal organizational reasons, it was placed instead under the 501(c)(6) organization. In addition, outside legal counsel advised that neither non-profit organization could be the contracting party for the Master Service CRADA. If they did so, it could be construed as providing access to valuable Laboratory services in exchange for membership dues only, which could possibly violate the "public good" test for both organizations. This problem was solved by creating the wholly-owned, for-profit subsidiary that ultimately was placed under Catalyst, the 501(c)(6) organization.

The CalCharge former Director estimated that CalCharge initially started with about $500,000 funding from CalCEF. The initial funding covered due diligence, formation, and launch costs, including legal fees, the EIR, marketing and communications, and personnel costs for a Director and partial coverage of two additional staff. Part of the initial funds, $300,000, was in the form of promissory notes that eventually will be paid back to CalCEF through revenue generated by CalCharge operations. Additionally, Berkeley Lab contributed the time that Venkat Srinivasan had worked on developing CalCharge, and the time that other Berkeley Lab staff, including attorneys and contracting staff needed to develop the Master Services Agreement. It is our understanding that the Berkeley Lab attorneys continue to provide some time to CalCharge and that the Laboratory contributes their time.

Once all program areas are fully operational, CalCharge's annual budget is projected to average $1 million with about 40-50 percent coming from member dues, and the remainder from special projects conducted for state and federal governments. By late 2015, there were two full-time staff and some in-kind contribution from Berkeley Lab, mainly involving legal and contractual advice.

CalCharge is a membership organization. By fall 2015, there were 16 members and CalCharge expected an additional six to eight members by year-end. Of the 16 members, 12 were corporations representing a mix of startups and multi-national corporations; other members included Berkeley Lab, SLAC, San Jose State University, the International Brotherhood of Electrical Workers, and the National Electrical Contractors Association. CalCharge member companies pay membership dues that range from $2,500 a year for startups to $50,000 a year for more established companies.

The CalCharge Master Service Agreement: In September 2013, CalCharge and Berkeley Lab finalized a specialized CRADA intended to enable CalCharge's member companies to more easily access services and facilities at Berkeley Lab than they would through traditional bilateral contracts. CalCharge's CRADA with Berkeley Lab effectively acts as a Master Services Agreement permitting CalCharge members access to Berkeley Lab without negotiating individual contracts. The scope of the CRADA is broadly defined, encompassing energy storage technologies and in order for projects to be covered under the Master Services Agreement, they must stay within that parameter. Each new member of CalCharge that wants to work with Berkeley Lab writes a statement of work and

CalCharge simply amends its CRADA with Berkeley Lab to include the new member and their statement of work. The Acting Director of Berkeley Lab's Energy Storage and distributed Resources Division and his team review each CalCharge scope of work/addendum to insure that it falls within the overall scope and intent of CalCharge's master CRADA. The critical difference is that Berkeley's CRADA is with CalCharge and not the individual member.

The master CRADA allows companies to engage with Berkeley Lab on projects of varying scales, while protecting their existing IP and granting first right of exclusive licensing for new innovations to the member for a pre-negotiated field-of-use. According to the Agreement, the member has the option to bar disclosure of generated information marked as Protected CRADA Information for up to five years and also retains pre-publication review rights for three years.

In the first 18 months that the Master Service Agreement was in effect, CalCharge executed six member agreements. The member agreements involved major companies Hitachi and Volkswagen and several emerging companies. The Master Service Agreement allowed member agreements to be processed in weeks compared to the months that are required to process CRADAs with Berkeley Lab. One user agreement was processed in only six weeks.

CalCharge more recently negotiated a similar CRADA with SLAC and with LLNL, which is almost identical to the Berkeley Lab Agreement.

Other CalCharge Product Development and Entrepreneurial Activities: CalCharge is setting up its product development area with Berkeley Lab's Venkat Srinivasan and others at Berkeley Lab. It will initially involve convening meetings around pre-commercialization issues. CalCharge also intends to build out some other activities, including developing training for industry and certificate programs.

CalCharge intends to play a central role in enhancing the innovation ecosystem by bringing together multiple stakeholders. In conjunction with Berkeley Lab, CalCEF, and various trade associations they have held meetings during the development of CalCharge, brought potentially interested parties to the Berkeley Lab and SLAC for tours, and arranged meetings with researchers and others. They conduct "networking with intent", bringing together 30-50 people from the national laboratories, universities and private sector to discuss a specific problem or issue. Energy storage has been one of their more successful focal areas.

Berkeley Lab, CalCharge and SLAC also have conducted three advanced manufacturing road mapping meetings, each involving 25-30 companies. Venkat Srinivasan felt that the road mapping functions were particularly important in focusing research development. In the near future, CalCharge intends to work on developing a "thoroughly vetted" roadmap with Berkeley Lab that will identify critical barriers in the energy storage areas. They will do so by convening focus groups with corporations and manufacturers, increasingly taking deeper dives into specifically identified areas.

While CalCharge initially focused on Bay Area institutions such Berkeley Lab, SLAC, and LLNL its plan was to expand the focus to include other national laboratories and universities throughout California. In late 2015, they announced the inclusion of the UC-San Diego as the first of these non-Bay Area partnerships. Others partnerships are in process.

Example: ORNL MDF: In order to develop and accelerate advanced manufacturing innovations that could be more rapidly deployed in the marketplace, EERE established MDF. Located at ORNL, the Facility conducts R&D and provides services in additive manufacturing, composites, energy storage, critical materials, lightweight metals, roll-to-roll manufacturing, and other critical manufacturing areas. It is composed of a main facility located on the ORNL campus, and two nearby offsite locations. The main site offers materials development, characterization, process technology and computational facilities. One offsite facility is co-located with the National Transportation Research Center (NTRC) in Knoxville, TN, and houses additive manufacturing, composites manufacturing and battery manufacturing laboratories. The second offsite facility is the Carbon Fiber Technology Facility (CFTF), located in the Horizon Center Industrial Park in Oak Ridge, TN, which focuses on demonstrating advanced technology scalability and production of market-development volumes of prototype carbon fibers. The CFTF serves as a hub for several public–private partnerships such as the Oak Ridge Carbon Fiber Composites Consortium, which involves more than 50 companies intending to accelerate the development and deployment of lower-cost carbon fiber materials and processes. MDF also participates in America Makes, the first NMII and has a lead role for IACMI, discussed later in this section.

MDF is part of ORNL's Advanced Manufacturing Program. MDF's technology transfer is handled by ORNL's technology transfer office, which has one staff person dedicated to the MDF portfolio. MDF's budget is about $11 million per year; the majority of funding is from DOE and this is matched by industry funding. Industry match is mainly in-kind, often involving equipment donations, and about $1-2 million is in cash for specific projects. At times, industry contributions involving in-kind equipment and cash exceeds DOE's input. Until 2015, MDF primarily managed competitively awarded projects, but now receives noncompetitive funding from DOE EERE, and as a result has aligned its programs with EERE's. Other funding involves SPP projects funded by DOD.

MDF has industry representatives working alongside ORNL researchers in the ORNL facility, and according to Alan Liby, Advanced Manufacturing Deputy Director "virtually everything that MDF does, it does with industry." MDF also has 70 UT interns working on site. While MDF does not have a formal advisory board, currently there is discussion about setting up one that would involve industry advisors. Industry road mapping is also an activity in which MDF will participate as part of MDF's work with IACMI and America Makes. Liby commented that MDF's challenge in identifying and meeting industries' needs (like other similar facilities) is "bandwidth"; that is, having enough staff to respond to industry demand. Due to its renown from a joint industry project that produced a 3-D printed automobile, there is no shortage of interest.

MDF work with industries through (a) projects involving core R&D, (b) industry collaborations and (c) education and training. MDF's core R&D funding is about $8 million annually, not including CFTF operations. Core R&D primarily is conducted through CRADAs with equipment producers, about $4.0 million is conducted as SPPs. While large corporations prefer single proprietary projects, MDF usually avoids these projects in order to maintain the ability to broadly disseminate results.

Industry collaborations involve exploratory technologies funded by EERE through a specific AMO project that provides MDF with $2 million per year for three years. This MDF program involves an open call and operates in two phases: Phase I provides $40,000; Phase II provides $200,000 of follow-on funding. DOE funding for both phases is matched by industry funds. The selection and funding are subject to DOE review and discretion. MDF provides a brief synopsis of the proposed project to EERE's AMO, which has ultimate approval authority. For this project, industries must accept a non-negotiable CRADA concerning the IP. According to the MDF Deputy Director, small companies typically do not have a problem with this arrangement; larger companies sometimes will not participate. The majority of companies in this program are SMEs. MDF's SPPs are growing and its "funds in" CRADA also is growing.

MDF also conducts education and training and currently is training 25-30 Boeing engineers. MDF is closely connected to community colleges in the state and the colleges have long-standing connections with ORNL. Other activities include tours of the facility for faculty and students as well as industrial tours that have increased substantially due to national publicity in MDF's production of a 3-D automobile. The table below shows the breakdown of MDF's funding.

MDF Funding (apx., FY 2015) = $11 M*
Core R&D = $8 M
  SPPs = $1.5 M
  CRADAs = $6.5 M
Industry Collaboration
  CRADAs = $2.5 M
Education & Training = $.5 M
***does not include CFTF operations funding.**

MDF has started to network with the other national laboratories, currently involving MDF's computational capabilities and working with LLNL and Argonne on advanced photon source R&D. In addition, there is funding from America Makes (the NMII) to ORNL that is distributed to other national laboratories.

The main MDF at ORNL comprises 40,000 sq. ft. of laboratory with additive manufacturing equipment used for R&D, testing and evaluation, and is best known for its 3-D printing equipment, which is some of the largest of its kind in the nation. MDF received national and international publicity for its work with Cincinnati Inc. in producing a 3-D printed automobile. It is now working with Local Motors in Tennessee to produce a 3-D car, and is working with the entire supply chain on the production. In the first half of 2015, it hosted more than 3,000 visitors. By late 2015, it had not yet been designated as a DOE user facility, but is expected to be so designated soon.

IACMI: IACMI, the fifth designated NMII, is $250+ million public-private consortium involving 122 companies, nonprofits, universities and research laboratories, led by the UT, Knoxville. IACMI is managed by the Collaborative Composite Solutions Corporation (CCS), a 501(c)(3) subsidiary of the UT Research Foundation. (UT-Battelle is the M&O contractor for ORNL.[58]) MDF is closely tied to IACMI. IACMI's CEO, Craig Blue, is also Director of MDF and ORNL's AMO. It is our understanding that ORNL's AMO and MDF worked closely with UT's Vice Chancellor for Research and Engagement, Taylor Eighmy, who served as the PI on the

[58] UT-Battelle, LLC, was established in 2000 as a private not-for-profit company for the sole purpose of managing and operating ORNL for DOE. Formed as a 50-50 limited liability partnership between UT and Battelle Memorial Institute, UT-Battelle is the legal entity responsible delivering DOE's research mission at ORNL.

IACMI proposal. Having MDF's Director serving as CEO also means that MDF will have a continuing lead role in IACMI's development and operations.

The Institute is developing low-cost, high-speed manufacturing technologies promoting fiber-reinforced polymer composites. IACMI's seven founding partners are UT- Knoxville, ORNL, NREL, Michigan State University, Purdue University, the University of Kentucky, and the University of Dayton Research Institute. Consortium members will invest more than $250 million over the first five years, including $70 million in federal funds and more than $180 million in non-federal funds. Non-federal funding levels likely include in-kind support valued at over $90 million from IACMI participants.

RAMP-UP: In 2015, EERE's AMO developed a unique $1.5 million program opportunity for teams of university professors and their students to engage in additive manufacturing research at MDF. The "Research for Additive Manufacturing Program - University Partnerships" (RAMP-UP) will select 10 university teams to engage in collaborative research projects in additive manufacturing that align with core projects at the MDF. Research funded under the RAMP-UP program also is intended to leverage existing capabilities and expertise at the participating universities to promote a collaborative effort. Research teams will be led by a university professor and include one to two students each. The RAMP-UP program additionally will support research staff for collaborative efforts in MDF. Funding for university teams for one year includes $100,000 (including overhead) for faculty salaries and expenses, $15,000 per student for summer internships, and $30,000 for MDF staff and materials. The deliverable for each team is at least one publication.

Example: AzTE: AzTE was established by ASU in 2003 to increase the flexibility and speed of ASU's technology transfer operations. AzTE was established as an Arizona LLC with the ASU Foundation as its sole member. AzTE additionally has a wholly-owned for-profit LLC.

The organization's budget today is $6-7 million per year, of which patent protection and salaries constitute most of its budget. AzTE currently has 14 employees including the Director and administrative staff. The Director reports to the ASU Foundation's CEO and indirectly to the ASU's VP for Knowledge Enterprise Development (Research). AzTE's Board is composed of the ASU Foundation CEO, VP for Knowledge Enterprise Development, ASU's general counsel, several entrepreneurs and venture capitalists.

AzTE has gone through several iterations, starting out as a unit within the University. In 2003, after President Michael Crow came into office, it was restructured as a separate legal entity that would act as the technology transfer arm for the University. The Director and top staff were recruited from industry, paid competitive salaries and provided with deal flow related incentives. This combination was intended to attract high-performing professionals, which it did. Initially operating with a venture mindset, the University's goal for the organization was to break even in five years. While AzTE was making significant progress toward this goal, issues arose for faculty and industry partners. Faculty particularly were concerned that AzTE's focus on near-term financial gain did not optimally support their interest to create cutting-edge research and secure early patent protection. Also, the breakeven goal and incentive plan created issues associated with industry deal structuring. Thus, in 2008, the organization was again restructured to embrace a different strategy and value proposition. According to the current Executive Director, Ken Polasko, AzTE now pursues a more balanced approach to technology transfer and is focused on assisting ASU, wherever it can, to accomplish its mission. The intent is to optimize ASU's performance with regard to any matters that involve the University's IP.

In addition to traditional technology transfer services involving invention disclosures, patenting and licensing, AzTE provides services for startups such as introductions to mentors, EIRs and funding sources. AzTE works closely with the University's Office of Entrepreneurship and Innovation, which focuses on student entrepreneurship. AzTE also is collocated and works closely with the Office of Knowledge Enterprise Development (OKED) that is responsible for research partnerships, entrepreneurship and economic development. The Director said that AzTE works with the University in a seamless fashion and that their mission "is to optimize ASU's research mission". The Director and staff spend substantial time with OKED to quickly find IP solutions for industry research contract issues. AzTE also participates in faculty recruiting, particularly involving faculty recruits who are entrepreneurial and want to understand entrepreneurial support and policies before they join ASU.

Other resources linked to AzTE's efforts are OKED's Entrepreneurship and Innovation program in which faculty inventors are matched with one of about 100 entrepreneurial and business mentors. Another program, the Furnace Accelerator, provides incubation, acceleration funding and mentoring to entrepreneurs who participate in a nine-month accelerator experience culminating in a Demo Day where teams pitch business plans to investors. The ASU Startup Mill is designed to allocate entrepreneurial resources in an efficient manner. High potential ventures are allocated more extensive and focused educational and mentor services and investor connections.

AzTE has developed a marketing strategy that, according to the Executive Director, has resulted in a higher probably of research engagement. They provide a team review of

University innovations that assesses market size, growth potential, competitive analysis, market risks, etc. They then target mainly SMEs involved in the value chains of larger companies. They market specific University innovations throughout this value chain, sometimes to thousands of companies, following up leads via telephone and subsequent visits. AzTE connects research faculty with interested companies that give the researchers feedback on their technologies, sometimes resulting in a change of research direction, sponsored research, and licensing. Their aim is not only to get commercial feedback on University innovations but also to create long-term relationships, and build the level of trust between a firm and the faculty. This is part of AzTE's "big picture" approach to the innovation continuum that involves identification of potential users, commercial feedback, sponsored research and licensing. AzTE has a reputation for creative relationships with industry. It will release an invention to a faculty inventor if AzTE does not feel that it can gain industry interest and if it does not compromise the University's research efforts.

Since AzTE's founding in 2003, the ASU's faculty has formed over 84 startups and been issued over 600 patents. After the formation of AzTE, the invention disclosures in energy-related disclosures increased ten-fold. In FY 2015, with a research base of over $450 million, ASU executed 88 licenses and options and 270 invention and copyright disclosures.[59] According to the Executive Director, a major reason for AzTE's success is that they have the full support and backing of the University President, who has allowed them to experiment, reframe and pivot several times over the organization's life. The Executive Director commented "you must have leadership that understands the value proposition of technology transfer beyond just revenue, the time and flexibility for experimentation in the university's ecosystem, and the patience to see the results."

Example: MIT Industrial Liaison Program: MIT's Industrial Liaison Program (ILP) is one of the best known and most successful of its kind. Established in 1948, it was developed to strengthen relationships between MIT and corporations. Operating as part of MIT's Office of Corporate Relations, it is a branded membership program that now involves 230 companies. These member companies account for about 40 percent of all corporate gifts and single-sponsored research expenditures at MIT. The program also works with Lincoln Labs, a Federally Funded Research and Development Center (FFRDC) managed by MIT, and serves as an interface between its ILP members and Lincoln Labs when appropriate.

ILP focuses almost exclusively on large corporations, and involves only a few nonprofit organizations and a couple of government agencies. There is a fee of $75,000 per year for

[59] Source: AzTE.

membership. ILP is a self-supporting program, and while representatives would not disclose the Program's operating budget, its membership fees alone would bring in about $17 million per year. ILP has about 50 staff, 30 of whom are Industrial Liaison Officers (ILOs). All ILOs have industry experience, and each Officer works with about eight to 10 companies.

ILP's main function is to provide access to MIT's researchers. At any given time, about one-third of ILP members are actively sponsoring research at MIT. Core activities for members involve ILOs developing an action plan, help in coordinating research management, and sometimes help in assembling multi-disciplinary teams. MIT also has a research portal that includes abstracts of research and pre-publications and is open to anyone. Other membership benefits include information and events in technology areas, discussing management strategies and facilitating recruitment of MIT students. ILP activities additionally provide access to MIT's entrepreneurial community through various events, and through a database of more than 1,000 startups. ILP sponsors a series of one to two day conferences, on-campus and around the world. They have themes aligning with corporate interests in science, technology, management, and other areas of MIT expertise, in which its members can network with faculty, startups, and other ILP member companies.

From the perspective of the university, it not only attracts very substantial research funding but also creates opportunities for faculty consulting and support of student internships and employment. According to an ILP representative, ILP's most important services are that it serves as a single point of contact for corporations and provides individualized plans of engagement. Further, the key to ILP's success is that they "listen to the company" and, as part of a university, they view both corporate members and faculty as "clients".

Example: Fraunhofer CSE & TechBridge: Fraunhofer Gesellschaft (FhG) (institutes) in Germany focus on applied research for industrial and government clients. It is expected that 70 percent of Institute funding be generated from contracts with industry or competitively granted government contracts. The ratio between industry and government contracts varies between the institutes, but each institute has an industry-funding target, typically at least 50 percent. Thirty percent of Institute funding is "provided as performance-based funding" and is tied to the amount of revenue the Institute earns from contract research.

Fraunhofer USA, Inc. was incorporated in 1994 and is a nonprofit 501(c)(3) subsidiary of the Fraunhofer-Gesellschaft organization in Germany. With headquarters in Plymouth, Michigan, Fraunhofer USA has an independent board of directors, and its mandate is applied R&D for the benefit of U.S. industry and economic development. Fraunhofer USA maintains nine research centers in the U.S., each of which is closely affiliated with at least one Fraunhofer institute in Germany. Its annual budget is about $50 million, and it receives some performance-based funding from its parent organization in Germany. Fraunhofer USA's research centers follow the same core model as those in Germany, with some minor modifications.

Fraunhofer Center for Sustainable Energy Systems (CSE) was founded in 2008 and focuses on applied R&D in energy technologies for buildings, solar photovoltaics, distributed electrical energy systems, and start-up assistance. The Center is located in the Boston area and employs 50 people full-time, about 40 of whom are engineers, many with PhDs. CSE representatives were hesitant to provide their annual revenue for this report, but a CSE representative said that the Center roughly receives about 50 percent of its annual revenue from industry, and the Center works with major corporations including Dow Corning and Microsoft.

Typical projects involve working on behalf of an industry partner that wants to conduct technology co-development or wants to pivot to a new product line. The Center also does U.S. federal government contracting, and has funding from DOE, particularly from the SunShot Initiative on "plug and play" solar photovoltaics system and helping local governments with solar installations. They have also received funding from National Institute of Standards and Technology (NIST) for specific projects involving energy standards.

CSE is affiliated with FhG Institute for Solar Energy Systems (ISE) in Freiburg, Germany, and is loosely affiliated with MIT, depending on specific projects being pursued. The Center also works with the University of New Mexico on projects and has done some solar related work with SNL.

CSE's R&D Center is described as a "living laboratory", located in a renovated, energy-retrofitted historic building including a pilot solar module fabrication line, dedicated thermal testing laboratory, and characterization and environmental testing equipment. It is open to the public and its first floor features an interactive educational exhibit that is designed to showcase new technologies in order to facilitate the adoption of commercial and residential energy-saving technologies. The Living Laboratory is a product of the

Building Technology Showcase, a collaboration of partners from leading building industry manufacturers and businesses who provided funding and donated energy-efficient systems, materials and services to the project.

Fraunhofer TechBridge: Commercialization Arm of Fraunhofer USA: TechBridge was started in 2010 as a commercialization program for Fraunhofer CSE. It mainly acts as an applied R&D contract research organization. TechBridge currently employs three full-time staff and in 2015 operated with a budget of about $700,000; their representative said that, based on commitments, their 2016 budget is likely to double.

TechBridge actively seeks to identify problems in major industries that can be solved through CSE researchers and by identifying and working with startups that can bring their expertise to add R&D value. If the work generates IP specific to the project, then FhG will own the IP. Depending upon the project, they will sometimes provide a non-exclusive, royalty-free option to the startup. TechBridge does not invest funding in the startups that it works with, but does assist them in linking to potential investors and corporate partners. TechBridge does not normally take an equity position in its clients.

Since 2008, Fraunhofer CSE has filed and licensed several patents in photovoltaic and building energy technologies, and report creating over 170 direct jobs and hundreds of indirect jobs in the clean energy technology center. CSE reports "supporting" more than 30 early-stage cleantech companies that have raised over $67 million in follow-on funding.

Attracting Non-traditional Funding for R&D Projects

The NMC affiliated with LANL provides a good example of how an affiliated, nonprofit organization can combine the laboratory's expertise with that of state and other universities to attract a variety of (non-core) federal agency and philanthropic research funding. It also provides a good example of how to structure sharing of laboratory staff for specific projects in the affiliated organization. Another example, the Berkeley Lab Foundation, shows a more traditional foundation structure designed to attract philanthropic funding to a national laboratory.

Example: NMC: The Consortium is a nonprofit 501(c)(3) organization fostered by and affiliated with LANL, that was established by the three New Mexico (NM) research universities -- University of New Mexico, New Mexico State University and New Mexico Tech. The Consortium has non-profit and academic standing for the purpose of federal and other grants. It was created to facilitate cross-institutional and inter-disciplinary research, and outreach to the private sector with the aim of producing economic development outcomes.

The Consortium was an outgrowth of institutes created when LANL was operated by UC. At that time, UC established institutes corresponding to specific UC campuses and areas of research. The UC M&O fee, about $8 million per year, was used as seed money to set up the institutes, and UC's Laboratory Directed Research and Development (LDRD) partly funded the institutes' operation. After a change in the M&O contract from UC to Los Alamos National Security, LLC[60], the institutes were reformulated and refocused to include the three NM universities, and NMC was established to coordinate collaborative research between LANL, the three state universities and other universities.

NMC interfaces with LANL and academic institutions through LANL's National Security Education Center (NSEC), a division of the Laboratory. Where private sector agreements are involved, NMC interfaces with LANL through its Richard P. Feynman Center for Innovation (LANL's technology transfer and strategic partnerships office). NMC's Board is composed of voting representatives from the three universities and nonvoting representatives from LANL.

LANL provides a base of funding from its overhead, about $700,000 per year, which partially supports NMC administrative costs, and joint education and program development activities such as workshops, summer schools, and internships. In addition, LANL contributes all or partial support for several staff in NSEC who work with NMC including an administrator, a contract administrator, finance analyst, the NSEC Director and Deputy.

The Consortium conducts about $10 million of research per year, about two-thirds of which is funded by (non-DOE) federal agencies and one-fourth to one-third by philanthropic funding. The academic, non-profit standing allows NMC to actively seek and receive grants from NSF, DARPA, NIH and other agencies. About $2.5 million comes from philanthropic foundations including Gates Foundation and Moore Foundation for portfolio projects. The research funding pays for about 150 full-time and part-time researchers.

Foundation funding is treated differently from federal and other funding since there often is a cap on overhead (for example the Gates Foundation will allow only 10-15 percent to be

[60] Los Alamos National Security, LLC is composed of four partners: Bechtel National, University of California, The Babcock and Wilcox Company, and URS Corporation.

used on overhead). In order to be able to cover more of the “real costs” associated with overhead, the Consortium typically includes an administrative or information technology (IT) person as a direct charge on the grant (this is a common practice of universities).

LANL also subcontracts for access to the NMC Biological Laboratory. The $1.6 million per year access fee paid by LANL to the NMC covers cost of Laboratory and office space for LANL researchers. The NMC provides general and specialized research equipment, technical support, materials and supplies, general and equipment maintenance, IT, purchasing, and safety infrastructure. The fee allows up to 30 LANL researchers and students (LANL employees) to work at the Laboratory. The NMC representative said that operational costs are less in the NMC laboratory space, which does not have the additional overhead costs associated with the more secure LANL main campus. NMC now owns the Biological Laboratory building, which was developed from a $2.5 million grant from the county’s economic development authority and $8.5 million in loans from the Los Alamos National Bank.

The Biological Laboratory is one of two buildings that constitute the NMC campus, which is located just “outside the fence” of LANL. The other building - the Los Alamos “Research Park” - is owned by a community organization; about one-third is occupied by NMC, one-third by LANL, and one-third is leased to UC-San Diego for engineering R&D. Two startups occupy some laboratory and office space at the Biological Laboratory and, in lieu of full recovery of space and use of equipment, NMC has taken a small amount of equity in the startups.

The staffing arrangements between NMC and LANL can take one of two forms: “Outside Activity” or “Joint Appointment.” Outside Activity is “a two paycheck model” in which the employee receives one paycheck from LANL and another from NMC. In this arrangement, a LANL researcher develops a proposal for a federal agency, asks NMC if they can get academic standing and submits the proposal through NMC as an “academic proposal”. About 30 LANL researchers have academic standing with NMC at any one time. The process is as follows: a request for academic standing is submitted by a LANL researcher to the Office of the (Acting) Director for LANL’s NSEC. Once a grant is awarded, a committee reviews the application to formally grant dual status. The review committee is composed of seven people including three LANL managers from science, legal and ethics offices. There additionally are conflict-of-interest and conflict-of-commitment checks. The employee’s contract with the NMC is normally the primary one; the NMC contract also can be secondary to a university that is primary grantee. Where IP is involved, the LANL-NMC Institutional Agreement grants IP ownership to LANL for inventions by a researcher employed by both the NMC and LANL. Regarding the individual NMC inventor, NMC has structured a slightly more generous royalty-sharing plan than LANL for inventors.

A "Joint Appointment" is a "single paycheck model" used for academic interactions including research grants through academic partners or the NMC. The researcher remains a LANL employee and is "lent" to NMC for a specific research or teaching project. In this case, NMC reimburses LANL for the employee's time. Similarly, the joint appointment may be used for federal funding to LANL for a project involving a collaborating academic institution's faculty member. In this case NMC, through LANL's NSEC, would contract with the university for the faculty member's time. NMC is the gateway to all universities, not only the New Mexico universities that are officially part of the Consortium. NMC has arrangements involving a number of universities in which the university is the primary grantee and NMC is a subcontractor; joint appointments are made with NMC. All joint appointments are done through LANL's NSEC, and NSEC negotiates the overhead rates.

The joint appointment model is based on ORNL's model. However, in ORNL's model, the Laboratory has a master agreement and negotiates directly with individual universities; in late 2015, ORNL has 47 agreements. ORNL has moved away from the "middle person" and Jim Roberto, ORNL's Associate Laboratory Director for Science and Technology Partnerships, believes that there are advantages in dealing directly with the research partner, particularly if issues arise. LANL and NMC may review this structure in the future.

In either of LANL/NMC's "Outside Activity" or "Joint Appointment" case, NMC projects are conducted using NMC facilities and are charged NMC overhead rates. These rates are lower than LANL's rates, and are comparable to typical university overhead rates.

There is a provision in the institutional agreement between LANL and NMC for an umbrella CRADA, but to date, it has not been implemented. The Deputy Director of NSEC, Alan Hurd, said that they are considering using an umbrella CRADA for private sector access to instruments in the NMC Biological Laboratory. The reader should note that LANL's Materials Science Division has a long-standing umbrella CRADA with Chevron and Proctor & Gamble corporations, and an Industrial Fellows Program with Proctor & Gamble.

Example: Berkeley Lab Foundation: In 2013, Berkeley Lab's M&O contractor, UC, established the Berkeley Lab Foundation as a separate 501(c)(3) organization to provide a way for philanthropic and other contributions to fund Berkeley Lab research. A donor has committed a $10 million endowment to establish the Foundation, and while the payout from that endowment builds, UC provides funding from its lab fee to cover the operating costs of the foundation.

Berkeley Lab Foundation is an official “support group” within the UC system. This gives the University oversight responsibilities, and it manages the Foundation’s funding. The Foundation’s Board of Directors is composed of leadership from Berkeley Lab and UC, including the Laboratory’s Director, general counsel, and CFO. From the time it was established, the President of the Berkeley Lab Foundation worked closely with Berkeley Lab’s Director, division directors, and other stakeholders to develop strategic priorities for the Foundation. (We discussed this aspect in detail earlier under “Preparatory Steps”.)

UC recruited a highly successful Chief Development Officer, Ivy Clift, from Stanford University. She reports to both the Berkeley Lab Director and the UC Vice President for National Labs, and most directly works with the Laboratory Director, who provides ongoing strategic input and feedback. There is additional frequent contact with the UC Vice President for Advancement, who is a Board member. Interaction with the UC Vice President for National Laboratories is related mainly to UC’s oversight responsibility, and the Foundation Director submits weekly updates to her. The UC President’s office also has been supportive, lending its name and support for Foundation events.

When developing leads for potential donations, other interaction involves the UC development office, division directors and scientific PIs at Berkeley Lab and UC. Since many of the scientists have dual appointments at Berkeley Lab and UC, the Foundation President believes that it is important to keep the Laboratory and University continuously informed and the leads carefully coordinated.

Through an agreement with UC, legal, accounting and other administrative support services for the Foundation are provided through the UC system. While establishing a truly stand-alone organization was considered, the UC consensus was that it would increase greatly the Foundation’s operational expenses and add risk. However, a Foundation that operates as part of a large administrative bureaucracy also has inherent drawbacks that can increase complexity and slow down operations. Moreover, the Foundation President warned that paperwork associated with national laboratories is “not foundation friendly” and some adaptations may need to be made.

By late 2015, there were three major gifts and a loan to the Foundation, with an additional gift expected soon in 2016:

1) The Gordon and Betty Moore Foundation contributed equipment to support the Berkeley Lab Laser Accelerator (BELLA), and the Laboratory's laser technology work. The contribution was intended to leverage additional federal funding for Berkeley Lab's applied physics activities.[61]
2) A loan from the Heising-Simons Foundation was used for major instrumentation investments in the Dark Energy Spectroscopic Instrument (DESI).
3) As individual donors, Mark and Liz Simons provided a gift of matching funds to establish the Heising-Simons Energy Nanoscience Fellows program that will be used in conjunction with the Kavli Energy Nanoscience Institute (ENSI) discussed below.
4) The Kavli Foundation contributed $10 million and UC Berkeley is raising equivalent matching funding for a total $20 million endowment for the Kavli ENSI. The Kavli Foundation is providing additional start-up funds for the Institute. The new Institute will focus on fundamental issues in energy science to study and manipulate nanomaterials.[62]

The funding associated with the first two contributions/loans was made through the Berkeley Lab Foundation rather than given directly to Berkeley Lab or UC because they were considered somewhat risky, and additionally could be construed as potential "augmentation" which is not allowable under DOE funding. Moreover, Berkeley Lab (in common with other national laboratories) has high overhead rates and while UC has the power to waive overhead costs for philanthropy, the Berkeley Lab cannot.

According to the Foundation President, the most popular area with potential donors involves fellowships for the Laboratory, particularly those focused on women and minorities. Since there is overlap between UC and Berkeley Lab research, the Foundation intends to work closely with the University over the next couple years to seek mutually beneficial contributions that focus on a "big picture investments." The Foundation President's advice to others considering a similar foundation is to view philanthropic fundraising as a long-term process. She commented that while philanthropic funding may come with fewer strings attached, the price is that the long development process involving

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[61] For more information, see: http://newscenter.lbl.gov/2015/09/21/desi-cd2/.
[62] For more information, see: http://kavli.berkeley.edu/about.

"dating", discovering where mutual interests lie, discussions, negotiations and, most importantly, increasing the comfort level of a donor in working with a national laboratory.

Accelerating Innovations and Promoting Entrepreneurs

One of the areas in which a laboratory-affiliated organization can add value to the laboratory's R&D is in the area of technology maturation and acceleration. As we have discussed, one of the major drawbacks in transferring and commercializing national laboratory technology concerns the low technology readiness level (TRL), which may make the technology too costly and risky for corporations and investors to transition to the marketplace. Other areas of concern include changing the laboratory culture to make it more entrepreneurial, and connecting the laboratory's innovators to entrepreneurial resources.

We present several examples from national laboratories and universities that address acceleration and entrepreneurship. Berkeley Lab's Cyclotron Road is an innovative program designed to attract entrepreneurial talent and innovations that add value to the Lab's R&D and move it closer to market. NREL's Innovation Incubator is a joint program with Wells Fargo that combines entrepreneurial talent with the Lab's R&D to develop, test and apply innovations to commercial buildings. TVC and the Industry Growth Forum are long-standing investor forums that showcase laboratory innovations; one is conducted by a nonprofit organization affiliated with SNL, the other is a NREL program. One university program - MIT's Deshpande Program - is designed to accelerate faculty innovations.

Example: Cyclotron Road: Launched in July 2014, Berkeley Lab's Cyclotron Road provides support for innovators working to develop and commercialize hard materials and manufacturing related, clean energy technologies. Cyclotron Road competitively selects a small cohort of energy-related innovators from across the country and embeds them in Berkeley Lab. The program provides the entrepreneurs with up to two years support in the form of a living stipend and access to Berkeley Lab facilities, tools, and expertise. Cyclotron Road staff provide targeted mentorship on technology and manufacturing challenges, and networking connections to internal and external experts who can serve as advisors, collaborators, and potential commercial partners and investors. During their time in the program, the innovators are expected to identify financing partners for next stage development and commercialization. Cyclotron Road's pilot phase (2014-16) involves eight innovators conducting research in six projects spanning various "hard" energy technologies with the potential to create new manufacturing-based industries.

Cyclotron Road's value is that it provides a resource base to support researchers in developing products and processes that generally are too applied for typical academic or national laboratory research, and yet too early stage to be supported by traditional venture capital. It operates in the transitional lab-to-market space, about two to five years out from the market. Cyclotron Road's Director, Ilan Gur, founded the program based on his experience as a former Program Director and cofounder of ARPA-E's Technology-to-Market program, and founder of two clean energy startups. Berkeley Lab committed most of the funding for the pilot program, with additional funding and in-kind support from DOE and regional partners.

The Cyclotron Road competition is open to any U.S. citizen, and projects must have the potential for long-term impact in enabling materials and manufacturing-based products and processes that advance DOE's mission. The program is primarily marketed through a public web site, DOE communications, and via energy-related incubators and organizations nationwide. In the selection process for the first pilot cohort, Cyclotron Road's web site received 20,000 hits and 150 applicants registered in only three weeks. Applicants completed a five-page application, which was peer reviewed. The program staff then conducted telephone screening of the top applicants, selecting 10 finalists for personal interviews by a selection committee, and ultimately choosing eight entrepreneurs. The peer review and selection committee involve internal and external technical experts, and include some business advisors. The selection process is conducted in close coordination with DOE EERE.

The pilot program initially was structured to support innovators by hiring them as Berkeley Lab temporary employees. This structure was problematic because any new IP developed by the innovators would by default be owned by the Laboratory, not by the innovators. Ilan Gur said that this structure deterred a large number of innovators from applying to the program, and the IP restrictions were seen as a major barrier to private sector engagement. In late 2015, Berkeley Lab formulated a proposed new organizational structure in which innovators would partner with the Laboratory under an umbrella CRADA. This structure would provide the IP framework to more effectively attract and support innovators, and still protect the interests of the Laboratory.[63] At the writing of this report, Cyclotron Road's structure still was evolving.

While a major aim of Cyclotron Road is to address the gap between early-stage energy technologies and commercial outcomes, the program focuses on providing educational and

[63] By the end of 2015, the proposed framework was pending DOE approval.

professional development opportunities through mentoring, techno-economic advice, and seminars featuring industry speakers. It is expected that these entrepreneurial support activities will continue to expand by drawing from the region's rich I&E ecosystem.

Example: NREL's Innovation Incubator: Wells Fargo provided NREL with $10 million over five years to launch a joint "Innovation Incubator" (IN2) program intended to foster the development of early stage clean technologies for commercial buildings. The program combines entrepreneurs with expertise from national laboratories, universities and regional accelerators in the areas of lighting, sensors and controls, space heating and cooling, windows, energy modeling, plug loads, and building envelope. It is designed to fill the gap between early-stage concepts to production for emerging clean technologies.

NREL and Wells Fargo identified clean technology startups, and in 2015 four companies were chosen from 80 proposals. An independent advisory board of industry leaders representing the commercial building sector, academia, community organizations, serial entrepreneurs and technical experts selected companies. The four companies compose the first of three funding rounds that will receive up to $250,000 for business development needs, research and testing support at NREL, and coaching and mentorship from Wells Fargo.

Selected companies are expected to meet technology milestones that they set with NREL. The companies will be able to use NREL facilities for development and will be able to field test their innovations in Wells Fargo buildings. NREL contracted with the selected companies using DOE's pilot ACT program. (Other national laboratories successfully using ACTs to date include Pacific Northwest National Lab (PNNL) and LLNL.)

Example: NREL's Industry Growth Forum: The Growth Forum is an event that has been held annually for the last 28 years and features presentations from emerging clean energy companies, as well as organized networking opportunities and panels. Private, one-on-one meetings are organized between startup companies and potential investors. Presenters can win commercialization services from NREL in addition to potential investment capital from private investors. The Forum receives funding from a variety of public and private sponsors, including Wells Fargo and the State of Colorado's Energy Office. Since 2003, companies who have presented at the Forum have raised financing worth more than $4 billion.

Example: Sandia's Technology Ventures Corporation: The Technology Ventures Corporation (TVC) was founded as a 501(c)(3) nonprofit charitable foundation by Lockheed

Martin in 1993, as part of Lockheed's M&O contract for SNL. TVC was created to commercialize federally funded technologies, and does not charge fees or take equity compensation for its services. TVC's operational costs are funded by a grant from Lockheed Martin, and it receives additional grants from federal agencies for related work in economic development and technology commercialization.

TVC accepts clients competitively, evaluating prospective ventures using typical investor criteria and giving extra weight to whether a client is attempting to commercialize technology from a national laboratory or university. TVC's primary vehicle for showcasing seed and early stage companies is its annual Deal Stream Summit, a vehicle to facilitate private investment in start-ups with lab-based technologies. TVC reports that one-third of all companies who present at its Summit have received funding.

TVC representatives believe that its status as a nonprofit organization, and its policy of not charging fees or taking equity promotes a broader outreach, and that it is perceived as an "honest broker" between investors and startups. Lockheed has touted its work with TVC as an example of its association with SNL moving beyond national security work to economic development. Lockheed reports that TVC's efforts have helped create more than 117 companies and created 13,500 jobs. TVC reports that its work has been key to the production of more than $1.2 billion in venture capital investments in those companies.

Example: MIT Deshpande Center: Established in 2002 through a gift from philanthropists Gururaj "Desh" and Jaishree Deshpande, the Center gives MIT researchers the funding and tools to bring innovative technologies from lab to market in the form of breakthrough products and startup companies. MIT faculty, student and other researchers with Principal Investigator (PI) status are eligible for a grant and services. Since its inception, the Center has reviewed more than 600 grant proposals, supported the work of 300 faculty, graduate students and post-doctoral researchers, and funded more than 125 projects with grants totaling more than $15 million. Thirty-two companies have spun out of the Center and have collectively raised over $600 million in capital. Nearly 30 percent of funded projects spin out a new enterprise.

The Center awards research grants and provides other types of assistance to faculty members whose work shows the potential to benefit society and transform markets and industries. It carries out several core activities: educating grant recipients about the innovation process; coaching grantees on how to commercialize their inventions and launch startup companies; providing research teams with mentoring and guidance from investors, startup specialists and entrepreneurs; nurturing MIT's I&E ecosystem; and assisting organizations that want to replicate MIT's Deshpande model.

The Deshpande Center grant program is conducted in two phases – Ignition Grants provide $50,000 for an invention which is at an early stage; Innovation Grants provide $50,000 to $150,000 for an invention which is within two years of moving out of MIT into a commercial entity. Grants are for one year and can be renewed over multiple years, for a cumulative maximum of $250,000.

A committee composed of entrepreneurs, investors from industry, and MIT faculty and staff, reviews proposals at the pre-proposal and full proposal stage. The Committee reviews pre-proposals and recommends whether to proceed to the full proposal stage, resubmit in the following year, or go back to the drawing board. At the full proposal stage, the Committee performs a more rigorous evaluation including a more detailed technical review. The Center's Catalyst Program involves volunteer mentors called Catalysts from the external I&E communities, who provide mentoring to grantees. Since inception, the Center has engaged more than 100 Catalysts and other volunteer mentors.

MIT's Technology and Licensing Office (TLO) works with the Deshpande Center grant recipients to foster investment while protecting IP rights. It participates in the Center's grant-selection process, advises grantees about judicious disclosure of information, manages patent applications, and licenses inventions to spinout companies and established firms. The TLO takes special notice of inventions coming from the Deshpande Center, as does the MIT $100,000 Entrepreneurship Competition, one of MIT's best-recognized business competitions. The MIT $100,000 Entrepreneurship Competition gives student entrepreneurs a forum in which to develop and hone pitches, demonstrations and business plans for new ventures that show significant business potential. Inventions that arise from these programs have already been vetted by expert evaluators and have a "stamp of approval". This is also the case with volunteer Catalyst mentors, who get a first look at Deshpande inventions as well as other angels and venture capitalists, who closely follow these programs and act favorably upon enterprises that spin out of them. The Deshpande Center also hosts an annual IdeaStream Symposium, an invitation-only showcase for new technologies coming from MIT that is intended to connect faculty and grantees with venture capitalists, successful entrepreneurs, investors, and other MIT researchers. [64]

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[64] Portions of MIT's Deshpande Program were extracted and updated from Innovation Associates' report *Accelerating Economic Development through University Technology Transfer*.

Desh and Jaishree Deshpande's support for the Center is grounded in decades of successful entrepreneurial ventures and innovative philanthropy.[65] Explaining their philosophy, Desh has commented, "We don't see a lot of difference between developing a new technology in the lab, starting a company, or engaging in philanthropy. All these activities are about making a difference."[66]

[65] Desh Deshpande is the President and Chairman of Sparta Group LLC and Chairman of Tejas Networks.
[66] Source: MIT Deshpande Center, 2015.

SUMMARY REMARKS AND NEXT STEPS

National laboratories have a window of opportunity to experiment with new methods that enhance industry partnerships, and accelerate technology transfer and commercialization. ANL's visionary Director and other national laboratory Directors intend to develop new paradigms by adding value to programs and practices started by other national labs, universities and institutions, and by creating their own brand of cutting-edge organizational methods and tools. New organizational structures such as laboratory-affiliated, nonprofit organizations offer potential opportunities to enhance private sector partnerships and commercialization by reducing risk, accelerating technology transfer, stimulating entrepreneurship, and providing a broader reach for the laboratory's R&D.

We have shown a number of exemplars from national laboratories and universities that could be adapted across national laboratories and, in some cases, we have suggested value added elements to enhance those programs and practices. Berkeley Lab's affiliated CalCharge provides a good example from which to start. As an affiliated, nonprofit organization, its membership structure and Master Services Agreement (umbrella CRADA) provide a means to increase industry partnerships and accelerate commercialization of Berkeley Lab's R&D. We suggested that this model might be expanded in several ways. The potential value-adds could include (a) creating inter-disciplinary R&D teams involving multiple corporations, academic institutions and national laboratories to address specific industry problems; (b) adding a highly focused laboratory that is designed to accelerate specific types of technologies spinning out of Berkeley Laboratory; (c) providing industry portal services for the full range of national laboratory R&D; and (d) creating an evergreen fund that would invest in potential spinouts.

Cyclotron Road is a promising program that should be considered for adoption by other national laboratories. This program could be operated by a laboratory-affiliated organization or other organization(s) under an agreement with the laboratory, which would provide greater flexibility than the original Cyclotron Road program and better IP terms that make it more attractive to external innovators. Cyclotron Road leadership has come to a similar conclusion, and the program is now being restructured to provide greater flexibility internally through an umbrella CRADA mechanism. We also have suggested a Cyclotron Road "Plus-up" that would provide follow-on matching funding for those innovators successful in attracting investment capital for commercialization. Funding for the match might come from the M&O contractor fee, LDRD funds, or philanthropic funding.

Other acceleration programs found at universities and elsewhere, such as MIT's Deshpande program, also could be applied either inside or outside of a national laboratory. In that vein, we suggested a “Phase II” to the Lab-Corps program. This follow-on phase would involve competitive selection of the most promising Lab-Corps innovators for targeted acceleration and commercialization funding and external mentoring.

Stronger engagement with industry should be a priority for all national laboratories, with an emphasis on building long-term relationships. An industry portal, similar to MIT’s ILP, could be conducted through a laboratory-affiliated organization, facilitating the use of membership fees for this service. An active industry advisory board for a laboratory-affiliated organization as well as for the national laboratory itself and its major divisions/centers also provides critical strategic input and facilitates private sector relationships. Industry road mapping for priority research areas should be part of any enhanced industry-partnering plan for both the national laboratory and its affiliated organization.

Connections among national laboratories could be strengthened. National laboratories that now view each other as competitors have much to gain in some areas by collaboration rather than by competition. National laboratories were very forthcoming and generous in sharing their exemplary practices with Argonne for this report, and in turn, Argonne is sharing this report on technology commercialization practices with others. We hope that the national laboratories will, at a minimum, continue to share their experiences, and will optimally join forces to build mechanisms and practices that benefit all.

On a national level, DOE, particularly EERE, is experimenting with various mechanisms to increase technology transfer, and they are to be commended for their leadership. Other DOE Offices are not yet following this lead. Early in the report, we enumerated impediments to national laboratory-industry partnerships and commercialization. National laboratory directors should join forces for a common call to address these impediments. The SEAB Task Force report issued in October 2015 is a step in that direction. We would encourage DOE to go a step further by convening industry leaders, including SMEs, entrepreneurs and VCs to explore further the specific areas targeted for improvement in the SEAB Task Force report as well as other recent reports, and to work with leaders in breaking down barriers and building new avenues for cooperation. There should be an ongoing dialogue in which the private sector can provide continuous input aimed at real change.

At the writing of these final words, Bill Gates and other philanthropists are announcing major commitments in renewable energy. There has never been a more propitious time to experiment with new paradigms that leverage our enormous national laboratory strengths to create energy breakthroughs that benefit us nationally and globally, now and for generations to come.

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APPENDIX

ORGANIZATION REPRESENTATIVES INTERVIEWED*

(*In alphabetical order by last name*)

Richard Adams, Director, Innovation and Entrepreneurship Center, National Renewable Energy Laboratory

Ian Anderson, Director of Graduate Education and University Partnerships, Oak Ridge National Laboratory

Jeffrey Anderson, (former) President, CalCharge and Managing Director, CalCEF

Jacqueline Ashmore, Lead, TechBridge, Fraunhofer Center for Sustainable Energy Systems

Craig Blue, Director, Advanced Manufacturing Office and Director, Manufacturing Demonstration Facility, Oak Ridge National Laboratory, and Chief Executive Officer, Institute for Advanced Composites Manufacturing Innovation

Benjamin Brown, Senior Science and Technology Advisor, Office of the Deputy Director for Science Programs, U.S. Department of Energy

Ivy Clift, President, Berkeley Lab Foundation

William Farris, Associate Laboratory Director, Innovation Partnering and Outreach, National Renewable Energy Laboratory

John Flavin, Executive Director, Chicago Innovation Exchange

Amy Francetic, (former) Chief Executive Officer, Clean Energy Trust

Tim Galpin, Assistant Director for Programs, Applied Physics Laboratory, Johns Hopkins University

Todd Glickman, Senior Associate Director for Corporate Relations, Industrial Liaison Program, Massachusetts Institute for Technology

Michelle Grdina, Program Manager, Deshpande Center for Technological Innovation, Massachusetts Institute of Technology

Ilan Gur, Director, Cyclotron Road, Lawrence Berkeley National Laboratory

David Hiller, Executive Director, The Collaboratory

Alan Hurd, Deputy Director, National Security Education Center, Los Alamos National Laboratory

Jerry Krill, Assistant Director for Science and Technology, Applied Physics Laboratory, Johns Hopkins University

Donald Levy, Vice President for Research and for National Laboratories, University of Chicago

Alan Liby, Deputy Director, Advanced Manufacturing Office, Oak Ridge National Laboratory

Peter Matlock, Director of Commercialization, Joint BioEnergy Institute, U.S. Department of Energy

Valerie McKinney, Communications and Content Manager, Technology Ventures Corporation

Steven McMaster, Deputy Director, Office of Technology Transitions, U.S. Department of Energy

Jackie Kerby Moore, Manager, Technology and Economic Development, Sandia National Laboratories

Kenneth Olliff, Associate Vice President for Program Development, University of Chicago

Mike Paulus, Director, Technology Transfer Division, Oak Ridge National Laboratory

Bill Peter, Deputy Director, Manufacturing Demonstration Facility, Oak Ridge National Laboratory

Kenneth Polasko, Executive Director, Arizona Technology Enterprises

Elsie Quaite-Randall, Chief Technology Transfer Officer, Lawrence Berkeley National Laboratory

James Roberto, Associate Laboratory Director for Science and Technology Partnerships, Oak Ridge National Laboratory

James Schatz, Head of Research & Exploratory Development Department, Applied Physics Laboratory, Johns Hopkins University

Ron Schoon, Executive Manager, Partnership Development, National Renewable Energy Laboratory

Bill Shelander, (former) Entrepreneur and Commercialization Expert, Lawrence Berkeley National Laboratory

Venkat Srinivasan, Staff Scientist, Energy Storage and Distributed Resources Division, Lawrence Berkeley National Laboratory and Deputy Director, Joint Center for Energy Storage Research

Allen Thomas, Associate Vice President and Director of the Center for Technology Development and Ventures, University of Chicago

Norma Lee Todd, Supervisor of the Technology Transfer Group, Applied Physics Laboratory, Johns Hopkins University

Libby Wayman, (former) Director, Clean Energy Manufacturing Initiative, U.S. Department of Energy

Ellen Williams, Director, Advanced Research Projects Agency - Energy, U.S. Department of Energy

Johanna Wolfson, (former) TechBridge Program Manager, Fraunhofer Center for Sustainable Energy Systems

Jetta Wong, Director, Office of Technology Transitions, U.S. Department of Energy

Michelle Chew Wong, Patent Attorney, Lawrence Berkeley National Laboratory

*The Appendix does not list all representatives interviewed, and does not include representatives from Argonne National Laboratory.