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AEIC Scaling Innovation Recommendations
A Proposed Framework for Scaling Energy Demonstrations and Early Deployment

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This document is a staff working paper of the BPC's American Energy Innovation Council. It is currently under review and will be released formally this fall.

"One often cited concern with tripling our innovation budget is: Where will this money go? Our answer is demonstration and deployment projects." – AEIC's 2020 report Energy Innovation: Supporting the Full Innovation Lifecycle

Introduction

The American Energy Innovation Council (AEIC) has been working since 2010 to advance policies aimed at strengthening America's innovation capabilities in clean energy technology. As decarbonization efforts gain momentum worldwide, leadership in developing and commercializing zero-carbon and negative carbon technologies are critical strategic and competitive priorities for the United States. The AEIC's Scaling Innovation Advisory Group, which includes entrepreneurs and experts from industry, finance, academia, and government, came together to focus on critical but often challenging steps in the innovation lifecycle: demonstration and early deployment.

This focus is prompted by a recognition that demonstration is often the weak link in transitioning a technology from the early stages of innovation (i.e., research and development) to a commercial product and mass deployment. Yet despite the importance of demonstrations—to develop critical technical and operational know-how and to reduce the project, operational, and financial risks associated with deploying a new technology—the federal government's track record of supporting early scaleup, large-scale demonstration, and deployment of commercial scale first-of-a-kind energy innovations is mixed at best.

How this track record might be improved through a strengthened and more focused federal role is the subject of this paper. Our central recommendations are for Congress to

(1) increase funding for the Advanced Research Projects Agency–Energy (ARPA–E) and bolster that agency's new Seeding Critical Advances for Leading Energy Technologies with Untapped Potential (SCALEUP) program focused on early scale-up and piloting technology and

(2) create a new independent federal institution—called, for purposes of this discussion, the Energy Demonstration and Finance Corporation (EDFC)—that would have the financial tools and project management capabilities to better support large-scale energy technology demonstrations and deployment.

The AEIC has been a strong supporter of ARPA-E and views the expansion of the agency's capabilities to pilot new technology as a statutory responsibility and key to filling the early-stage demonstration gap. The SCALEUP program can help bridge the valley of death between research, development and demonstration by supporting earlier scale-up and pre-pilot projects and helping to advance technologies along the innovation lifecycle. Few other entities have the flexibility and expertise to conduct this important activity, yet it is impossible to move into large-scale demonstration without performing these critical steps in the innovation process. Through ARPA-E's SCALEUP program, a robust pipeline of technologies will be ready for large-scale commercial demonstration and deployment supported by the EDFC highlighted below.

The creation of an EDFC would be a monumental change in how the U.S. commercializes energy technologies. This wholly-owned government corporation would combine the project development and large-scale demonstration capabilities of the (proposed) DOE Office of Clean Energy Demonstrations and Loan Program Office, the financing tools of the (proposed) Clean Energy Deployment Administration (CEDA), and the governance structure of both the (proposed) Energy Technology Corporation (ETC) concept and the (actual) International Development Finance Corporation (DFC).

In particular, with respect to the creation of a new EDFC, the AEIC recommends:

- an initial congressional authorization and upfront appropriations of $60 billion for at least 10 years of operation,
- a focus on large-scale demonstration and early-stage deployment of advanced energy technologies,
- an independent board of directors nominated by the president and with the advice and consent of the Senate to govern the organization,
- special hiring authority to attract individuals with energy sector experience who have specialized financial and technical skills, including individuals outside the professional civil service system who could be hired on a temporary basis at commercially competitive salary levels,
- granting the organization a broad set of financial tools, including contract, grant, and cooperative agreement authorities as well as an ability to provide direct loans, loan guarantees, letters of credit to provide security for a project's offtake agreement in the event of default, equity investments, insurance products, securitization for resale, and other means of secondary market credit enhancement.

Establishing the EDFC would be a natural step in DOE's evolving approach to supporting the energy commercialization and the innovation process. In the short-term, strengthening DOE's loan programs and launching a new Office of Clean Energy Demonstrations within DOE will help build financial and project management capabilities and fill important gaps in the existing innovation system. In the long-term, the EDFC, as an independent agency, would better coordinate and execute these capabilities in one entity that has a degree of additional freedom from political interference.

The ARPA-E early pre-pilot demonstration and the EDFC large-scale demonstration and deployment proposals complement previous AEIC recommendations, which call for tripling the federal government's overall investment in energy innovation, growing ARPA–E's budget to $1 billion per year, and creating a New Energy Challenge Program[i] to demonstrate energy breakthroughs at commercial scale.

To provide context for these recommendations, we begin by reviewing AEIC's work in 2020 on large-scale project demonstrations, then we outline the case for a meaningful federal role in closing the demonstration and deployment gaps. This paper concludes with an overview of the Energy Demonstration and Finance Corporation concept in more detail and connects this proposal to experience with existing institutions and to similar concepts that have been proposed elsewhere.

AEIC Scaling Innovation Project Paper Development

The AEIC Scaling Innovation Project is focused on addressing the challenges inherent to the scale-up and demonstration of new energy technologies. This paper is the culmination of a series of case studies and workshops developed and conducted over the course of 2020 examining the role of demonstration projects in the commercialization of new clean energy technologies.

A Scaling Innovation Advisory Group, which includes entrepreneurs and experts from industry, finance, academia, and government, came together to advise the AEIC on the critical but often challenging steps in the innovation lifecycle: demonstration and early deployment. Between March and November, AEIC held seven workshops on the need for greater federal support for demonstrations and deployment. The Advisory Group invited guest speakers from DOE, investment groups, private companies, and think tanks to highlight critical barriers to large-scale demonstration and deployment of new energy technologies. Several federal programs, with successes and failures, were analyzed for lessons. While critical characteristics and capabilities began to emerge, important conversations were also being held related to political feasibility and appropriate timing of a new policy proposal.

The AEIC series of four case studies examined the role of demonstration projects in the commercialization of new clean energy technologies.[ii] The case studies included:

1. *A Review of Federal Efforts to Demonstrate Carbon Capture and Storage with Commercial-scale Coal-based Power Plants (2003-2016)*, by Eric Redman, and highlighted DOE's management challenges and the high cost of political interference in the demonstration of new technologies.

2. *The U.S. Clean Energy Deployment Administration: A Business-Driven Approach to Leveraging Private Sector Investment in Clean Energy Innovation and Commercialization*, by Dan Reicher, showcased the political feasibility of Clean Energy Deployment Administration and the value it could bring to the deployment of new technology by using unique financing mechanisms.

3. *The American Recovery & Reinvestment Act and the Rise of Utility-scale Solar Photovoltaics: How U.S. Public Policy during the Great Recession Launched a Decade-long Solar Boom*, by Varun Sivaram, described the origins of the commercial scale solar energy expansion in the US and the Loan Program Office's important role. In particular, the case study revealed the significance of complementary policies and the importance of this new DOE program that filled a critical early deployment gap and had an ability to hire both technology experts and private sector project financing experts.

4. *Flying Laboratories, Prototyping, and Dem/Val: The Crucial Role of Technology Demonstration in Advancing Military Innovation and Its Relevance for the Department of Energy*, by Dorothy Robyn, examined how partnerships between DOD and the private sector can facilitate the commercialization of specific technologies, especially when projects are developed using commercial practices and when industry is given more control. Additionally, the study highlighted how the process to scale certain critical technologies requires significant funding, attention, and political cover from the federal government.

The workshops, along with the case studies, and many one-on-one conversations provided a solid foundation for the recommendations contained in this paper. Furthermore, the Scaling Innovation Advisory Group was an important sounding board for ideas and feedback. The group considered both technical and political challenges to overcoming major barriers to demonstration resulting in the recommendations contained here which we acknowledge are a combination of pragmatism and ambition.

Stages of the Innovation Lifecycle

An extensive literature on innovation describes the key features and challenges associated with each of the research, development, demonstration and deployment (RDD&D) stages of the innovation process, and their relationship to each other. Previous AEIC reports highlighted that the path from the lab bench to wide-scale deployment of new energy technologies is arduous and can require decades of effort and hundreds of millions, or even billions, of investment dollars. A more comprehensive approach to the full innovation lifecycle—encompassing not only research and development, but also demonstration and deployment—can help ensure that the United States remains home, not only to the inventors of tomorrow's critical energy technologies, but also to the companies that build, manufacture, and export those technologies to the world.

The research and development stages, funded largely by the public sector, are where discovery and invention happen. These stages receive relatively little private sector investment because the probability of success is uncertain, technology risk is high, and there is usually a lack of commercial pull. Federal support for research efforts (both basic and applied) at national labs and universities is necessary to address the market failure of inadequately pricing the benefits of future technology deployment.

The pilot stage is where small-scale pre-commercial integrated systems are created as a technology proof of concept, resulting in important technology de-risking. In this stage, project developers can conduct the initial tests of their technologies under highly controlled settings (*not* in real-world settings or at scale) to evaluate the technologies and sort through any emergent issues that appear, including issues that require additional research and development.

The large-scale commercial demonstration stage is where fully integrated, "first-of-a-kind" projects are implemented on a commercial scale under real-world conditions. At this point, the roles of the private and public sector intersect; private entities must be intimately engaged with the design and operation of demonstration plants and the public sector must help defray their costs and risks. The primary focus at this stage is on developing *technology* capabilities and proving commercial viability. Lessons learned from large-scale demonstration projects directly inform the next stage of early deployment, which typically involves the first set of replicable "n^{th}-of-a-kind" projects and where the focus is on improving *financing* means and driving down costs through multiple iterations of the same or similar designs. Demonstration projects are particularly challenging because they generally have large and concentrated capital requirements but, since they are test facilities, they are not expected to deliver optimized cost or performance. Additionally, one of the challenges to industry is that it already has huge investments in long-lived infrastructure, and that creates a very high bar for demonstrating new technology. The specific importance of large-scale demonstration projects has been summarized as follows:

> "*The fundamental role of demonstration is to instill confidence in technology developers, users, investors, and other stakeholders that a technology will perform predictably from both a technical and economic perspective. Knowledge and data created by demonstration projects reduce the risks that stakeholders perceive themselves to be taking in follow-on projects that deploy the same technology*." – Robert Rozansky and David M. Hart. *More and Better: Building and Managing a Federal Energy Demonstration Project Portfolio*. ITIF, May 2020.

Although the innovation process is often described in RDD&D stages, the process is not linear, the stages are not concrete, and it takes many different players and partners to commercialize a new technology. Finally, there is not a clear dividing line between a large-scale demonstration project and a first-commercial deployment. In fact, these different kinds of projects require different skills, funding mechanisms, and partnerships. Aligning all these moving pieces is the challenge.

Challenges in the Innovation Process

Technical and operational confidence is important because, in marked contrast to many consumer products, taking an energy innovation from lab pilot scale to large scale is rarely a simple, additive process. Instead, it often requires the integration of numerous and diverse components and subsystems, all of which may interact at large scale in ways that cannot be anticipated in the laboratory or even in a pilot plant. Not infrequently, unexpected challenges emerge that require further technical changes or process adjustments. A complex, tightly coupled system such as a coal plant with gasification and carbon capture, for example, or a smart grid, may also be vulnerable to breakdown if a

single component or subsystem fails. In these cases, building and operating a large-scale demonstration plant allows for the learning-by-doing that is needed to successfully resolve technical issues and build confidence in the performance and operation of the technology or system at scale.

Economic confidence is likewise critical to attract the early investment needed to support new energy technology commercialization and mass deployment, particularly for projects that require large, upfront capital investment. Other external factors such as regulations, policy, political factors, and a lack of experience create uncertainties in construction timelines and permitting that add to investor perceptions of risk. Regulatory barriers are particularly challenging as the pace of developing and deploying new technologies increases quickly. Additional economic risk can arise from uncertainties about technology performance at scale: a project may work perfectly for a period but then prove vulnerable to operational failures that are difficult or time-consuming to resolve. Often these risks alone, combined with the potential for delayed payback, are enough to keep private sector financing out of demonstration and early deployment altogether.[iii] Many innovative technologies also encounter major headwinds when entering the market and have trouble displacing incumbent technologies, even if the incumbent technologies are inferior. Risk aversion among investors and customers, lack of familiarity, lack of clear near-term market signals, and lack of a track record of commercial success are typical and often potent barriers. Greater federal support to address this market failure can help ensure that project developers are better able to de-risk their technologies and successfully demonstrate technologies at scale and economic viability, which may then mitigate some concerns raised by potential investors or partners from the private sector.

Large-scale demonstration projects are also fraught with political and management challenges, making it difficult to adopt an incremental approach that avoids picking technology "winners." One problem is that federal support for large-scale demonstrations has been inconsistent and sporadic, with extended periods of minimal funding. To the extent that resources have been available, program priorities have shifted frequently, often in response to political pressures, as described in the text box below. As projects scale, they become more prominent to the public, which makes failures more notable and increases risk aversion often seen in federal employees, both in the selection and termination of projects.

A Case Study in Political and Management Challenges

The BPC case study developed by Eric Redman, *A Review of Federal Efforts to Demonstrate Carbon Capture and Storage with Commercial-scale Coal-based Power Plants*, showcased political and government management challenges of demonstration projects. The DOE Clean Coal Power Initiative (CCPI) and the FutureGen project were high-profile energy demonstration programs from a decade ago. All the projects were designed to demonstrate carbon capture and sequestration (CCS) at large coal-based power plants. Only one project could be considered successful. These projects suffered from typical cost and scheduling problems of first-of-a-kind demonstrations and government policies and management practices were not suited to overcome those challenges. More flexible financial incentives and more time could have significantly improved the probability that the projects would have been successful. Additionally, coal-based CCS programs were not consistently supported

between administrations and by Congress, as illustrated with the FutureGen project below. Finally, policy incentives were not based on clear public policy, instead they were cobbled together to support multiple challenges including carbon emissions, low employment during the Great Recession of 2008, and a struggling coal industry.

DOE's signature project was FutureGen. It was proposed in 2003 as a demonstration of an integrated gasification combined cycle power plant with carbon capture and sequestration and hydrogen production. Selecting the location of the project turned the demonstration into a national competition, especially between Texas and Illinois, with potential states looking at the project as a major public works opportunity. Rumors were that Texas was to be selected, but when the final decision was announced, and it was Illinois, suspicions of political interference arose when the Bush administration pulled its funding. While the Bush administration maintains that it was responding to escalating cost estimates, onlookers were not convinced. The project was later revived by the Obama administration with a simpler design. Nonetheless, the project suffered numerous delays and problems and was eventually terminated in 2015, after an expenditure of over $200 million in DOE funding.[iv]

A further problem is that many large publicly supported projects present inherent technical and management challenges that government energy offices do not always have the skills to manage. A notable exception is the Loan Program Office and its financing of the first five utility-scale photovoltaic (PV) projects larger than 100 megawatts. Part of its success was due to LPO's ability to quickly amass considerable technical and financial expertise to conduct rigorous due diligence of proposed projects. Once private investors had initial experience with LPO-backed solar projects, they were more comfortable funding these projects independently without the need for federal loans or loan guarantees. Without this expertise, it is difficult for the government to deal with project developers that have the tendency to underestimate costs and overpromise performance. Once underway, projects can be difficult to terminate, even when they are unlikely to succeed.

In light of these challenges, the government approach for managing and financing demonstration projects must be systematic, patient, risk-tolerant and risk-sensitive, and structured in a manner that brings in private sector participation.

Policymakers in Congress and the executive branch increasingly acknowledge this approach and the need for federal support of all the stages of the innovation lifecycle, particularly to better accelerate the pace of the energy transition and position American companies to successfully compete in the emerging international clean energy marketplace. Consequently, there is a renewed focus on this topic in the current Congress[v]. Over the years, the federal government has implemented programs to pilot and demonstrate new technologies. Unfortunately, from synfuels and biofuels to carbon capture technologies it has not yet successfully developed a consistent and successful model. As the Breakthrough Energy report from 2019 states, "the track record for DOE-funded demonstration projects is mixed," especially with respect to commercial-scale demonstration projects.[vi] The AEIC's

Scaling Innovation Advisory Group case studies from summer 2020 provide further analysis in support of this conclusion.[vii]

The Energy Act of 2020, which passed in December 2020 as part of the 2021 Consolidated Appropriations Act, authorized [viii] significant funding for the U.S. Department of Energy (DOE) with a priority on demonstration and early deployment efforts in several areas, including energy efficiency, advanced nuclear technology, renewable energy, energy storage, carbon capture, carbon removal, and grid modernization. To implement these programs the President recently proposed an Office of Clean Energy Demonstrations in the FY2022 budget request (discussed below).[ix] How DOE intends to implement this office remains a key question.

Foundations for A New Approach

Many proposals have been put forward to better address the challenges identified above and strengthen federal support for demonstrating and deploying new energy technologies at scale more broadly. Several of these proposals target financing mechanisms and project management capabilities—two key hurdles at this stage of the innovation lifecycle; some proposals also attempt to address well-known shortcomings in the current federal approach with respect to program consistency, budget stability, and political independence.

In 2008, for example, Senators Jeff Bingaman (D-NM) and Lisa Murkowski (R-AK) introduced legislation that would have created a Clean Energy Deployment Administration (CEDA) to provide broad direct and indirect financing authorities for early technology deployments.[x] In 2011, John Deutch, for the Brookings Institution's Hamilton Project, proposed a quasi-public new entity, the Energy Technology Corporation (ETC), that would finance and develop demonstration projects in collaboration with industry.[xi] Many groups have advocated for the creation of a national green bank or climate bank to advance the mass deployment of clean energy technologies and climate resilient infrastructure. And the Information Technology and Innovation Foundation (ITIF) has proposed creating an "Office of Major Demonstrations" within the U.S. Department of Energy to manage demonstration projects in collaboration with industry.[xii] With respect to addressing the challenges in the energy space, the proposals take different approaches to navigating these issues.

Most recent attention has focused on creating programs and institutions with varying degrees of independence from political pressures. There is precedent for this. Congress has created numerous entities with new flexibilities and governance, accountability, and transparency requirements. These include traditional executive departments with unique capabilities, like special hiring authorities, quasi-governmental independent nonprofits, and wholly-owned government corporations.[xiii] The most recently created wholly-owned government corporation is the Development Finance Corporation (DFC), which finances projects in developing countries (see text box for more detail). The wholly-owned government corporation appears to be gaining in popularity. Evidence of this is Senator Coons' call to create an Industrial Finance Corporation of the United States (IFCUS), a wholly-owned government corporation, focused on financing high-tech manufacturing.[xiv] These quasi-governmental entities can have legal characteristics of both the government and the private sectors. A 2011

Congressional Research Service report, *The Quasi Government: Hybrid Organizations with Both Government and Private Sector Legal Characteristics,* describes major factors which have spurred the creation of quasi-governmental entities. Some of these factors include "the desire to avoid creating another federal bureaucracy," the tightening "controls on the federal budget that encourage agencies to develop new sources of revenues," and the interests of stakeholders for specific agencies and programs to be exempt from central management laws, especially statutory ceilings on personnel and compensation."[xv]

Addressing these factors by exempting new institutions from specific federal requirements or by separating the entities from direct public oversight provides varying levels of independence. Yet, in most cases these institutions are never truly free from congressional or executive branch influence. Likewise, political appointees of a president also have the ability to influence budget requests, program development, and agency policy. Additionally, oversight can be obtained through the creation of a board where members are selected by a secretary, the Senate, or the president. These protections create tradeoffs around funding certainty, political viability, and accountability.

International Development Finance Corporation (DFC)

While not energy focused, the U.S. International Development Finance Corporation (DFC) is another important institutional model. The DFC is a relatively new, wholly-owned government corporation under the guidance of the State Department. The DFC finances and facilitates financing for private development projects in lower- and middle-income countries. It was authorized in the bipartisan Better Utilization of Investment Leading to Development of 2018 (or BUILD Act), which merged the Overseas Private Investment Corporation (OPIC)[xvi] and the Development Credit Authority (DCA). Operations began in December 2019.[xvii]

The DFC has a lending authority of $60 billion, a onetime authorization for seven years, to provide loans, loan guarantees, insurance, equity investments, and other special mechanisms. These products are backed by the full faith and credit of the U.S. government and used for development projects undertaken by U.S. businesses in lower-income countries. In April 2021, the DFC announced it would target climate mitigation, adaptation, and other solutions, in addition to the other priorities of the State Department.[xviii] The DFC's regular operations are largely self-financed through fees and interest collected on DFC loans.

The DFC's unique authorities are balanced with additional oversight requirements. The DFC leadership structure is notable for its mix of public and private sector leaders. The Office of the Executive includes the CEO, COO, Deputy Chief of Staff, in addition to the Senior Advisor to the CEO. There are about a dozen other executive staff members. The Board of Directors includes the DFC CEO, the Secretary of State, the Administrator of USAID, the Secretary of Commerce, the Deputy Secretary of the Treasury, and board members from the private sector. All board positions are presidentially appointed and subject to Senate confirmation. For increased accountability, Congress required the DFC board to establish an independent accountability mechanism and annually report

to Congress on the corporation's statutory mandates. While exempted from the Federal Advisory Committee Act, there is also a Development Advisory Council, which includes leaders from the international community, as well as the private sector.

The strong connection to the private sector requires clear conflict of interest rules. The DFC adheres to regulations and guidance of the Office of Government Ethics and has created internal policies to avoid and address potential conflicts of interest. Additionally, the DFC management team and board of directors submit public financial disclosure reports like other government officials.[xix]

With respect to addressing the energy sector, the governmental and quasi-governmental proposals and existing organizations below take different approaches to addressing gaps in the innovation process. The section is broken into demonstration and deployment proposals, with a focus on governance, funding, political viability, and independence from the federal government.

Demonstration Models

ARPA-E SCALEUP

The Advanced Research Projects Agency for Energy (ARPA-E) is an independent agency within DOE that takes an innovative approach to funding transformative, early-stage energy research. ARPA-E offers a streamlined, competitive grant process to innovative energy technology developers seeking to advance their concepts.

ARPA-E's special hiring authority enables it to select program managers with expertise, enthusiasm, and novel approaches to supporting projects. These managers are only able to stay with ARPA-E for three years, meaning they move more quickly on projects and have a greater risk tolerance relative to other portions of DOE. This has led to tremendous technical gains from ARPA-E and its grantees, with a reverberating impact on DOE culture. Additionally, while ARPA-E relies on annual appropriations similar to the rest of DOE, it has more budget flexibility than the applied energy offices at the Department.

ARPA-E also has the capability to support innovators beyond research and development to include pilot demonstration projects. Notably, the new Seeding Critical Advances for Leading Energy technologies with Untapped Potential (SCALEUP) program can help bridge the valley of death between research, development and demonstration by supporting scale-up or pre-pilot projects and helping to advance technologies along the innovation lifecycle. The SCALEUP program is focused on supporting high-risk, high-reward scaling efforts to help test the integration and operation of early-stage technologies. Awards between $1 and $10 million with a 50% cost share help drive down costs, demonstrate performance, and provide essential information to investors and other partners for the next steps in the commercialization process.

ARPA-E's independence and special authorities allow its SCALEUP program to be flexible and adaptive to the needs of project developers. Thus far, the new program appears to be popular and over-subscribed, but results are not yet in. Furthermore, it is currently limited to previous ARPA-E grantees because the program itself is still under development.

Proposed DOE Office of Major Demonstrations

A $400 million new Office of Clean Energy Demonstrations (OCED) is proposed for DOE in the President's FY2022 budget request. This office would focus on bringing innovative cross-cutting technologies to the market and coordinating activities across the agency. If funded, the first round of projects would focus on storage technologies. This proposal is similar to the proposed Office of Major Demonstrations (OMD) as a new office within the Department of Energy, an idea put forward by the Energy Futures Initiative and expanded upon by the Information Technology and Innovation Foundation (ITIF), that would manage a portfolio of large-scale energy demonstration projects of unproven technologies across various areas that would otherwise be managed by DOE's applied offices. ITIF notes that while the staff in applied energy offices are technical experts and highly capable of managing a technology-specific R&D portfolio, this does not necessarily translate into proficiency for the management of large-scale demonstration projects. The OMD would have flexible hiring authority, like ARPA-E, so that it could employ individuals with backgrounds in commercial project management and project finance, who would then coordinate with staff in the applied energy offices, as well as with stakeholders outside of government. These individuals would have both the authority and financial expertise to continue or terminate large-scale demonstrations depending on the project's success.

In addition to close collaboration with the DOE applied energy offices, the aim would be for OMD to complement the Loan Programs Office, which is currently focused on technology deployment. OMD's funding would come from the standard annual congressional appropriations process. Awardees would enter into tailored cost-sharing agreements that would take into consideration the unique features of each project to better support project developers.[xx] OMD would require some reorganization within the Department, but because it does not require the establishment of a new agency and a large upfront investment, its authors believe it to be more politically feasible than other proposals with similar intent to demonstrate new technology through more independent authorities.[xxi] Some evidence of this perspective on political feasibility of the OMD can be seen from the $200 million and $100 million appropriations provided by the House and Senate Appropriations Committees, respectively, in their Energy and Water Development Subcommittee markups for the OCED. Additionally, the Bipartisan Infrastructure Deal, the Infrastructure Investment and Jobs Act (H.R.3684), which passed the Senate, creates and funds with $21.5 billion the new OCED.[xxii]

Yet, this proposal does not ensure a smooth hand-off between large-scale demonstration and first deployment. Nor does it have flexible financing authorities to overcome the financial hurdles at the end of the innovation process. Additionally, as a new office within DOE, it would be beholden to typical political influence, long budget cycles, and potentially stifling oversight from OMB.

Proposed Energy Technology Corporation (ETC)

Originally proposed by John M. Deutch in the Brookings Institution's Hamilton Project in 2011, the Energy Technology Corporation would be a quasi-public independent corporation focused on large-scale demonstration of new and unproven energy technologies. It would not be an agency or instrument of the federal government. It would be separate from government management. It is modeled on the government-funded Synthetic Fuels Corporation from 1980.[xxiii] Its objective would be to conduct large-scale demonstrations of technologies and then to provide technical and economic performance information from those demonstrations to the private sector. A similar model was described by AEIC co-chair Norman Augustine in 2020 at a National Academy of Sciences webinar on *Enhancing Federal Clean Energy Innovation.* In that discussion, he proposed, "the creation of a nonprofit bridge organization to facilitate the private sector in conducting large-scale demonstrations," akin to In-Q-Tel.[xxiv] This organization would be mostly funded by the government and would focus on large-scale demonstrations. Most importantly, it would be managed independently of the government and operate under commercial laws and regulations. .[xxv]

To provide flexible financing, the ETC would deploy a variety of finance mechanisms including guaranteed purchases, loan guarantees, production tax credits, and cost-shared reimbursements. The ETC would receive a one-time appropriation on the order of $60 billion with each project projected to receive funding on the order of $3 billion. Funds recovered from loans would be made available for reinvestment. Depending on performance, further funding might be extended.[xxvi]

As a public corporation, the ETC would not be constrained by the general management practices of the federal government including federal hiring practices and acquisition regulations. This would allow the ETC to operate under standard commercial practices and more easily obtain the technical and financial expertise to conduct strong project management. It would also have full responsibility to select and manage its own projects. Additionally, since the ETC's priorities and direct decisions would not be influenced by Congress or the executive branch, it would be partially insulated from political interference.

The tradeoff for this independence, large up-front funding, and remarkable financing authorities, is that the ETC would not have access to the faith and credit of the U.S. government. Governance of the ETC would also consist of an independent board of eight directors, nominated by the president and confirmed by the Senate. Currently, an independent organization such as the ETC, has not been discussed seriously by Congress and appears less politically feasible. Finally, while the ETC is laser focused on the large-scale demonstration gap, it doesn't have funding mechanisms that would help deploy new technology.

Deployment Models

Loan Programs Office

DOE's Loan Programs Office (LPO) has played an important role in supporting the deployment of energy technologies at commercial scale. LPO's Tribal Energy Loan Guarantee Program, Advanced Technology Vehicles Manufacturing Loan Program, and the Title XVII Innovative Energy Loan Guarantee Program were originally authorized in the Energy Policy Act of 2005. These programs provide financial support to projects that have difficulty obtaining private investment because of concerns around technological risk, cost of capital, and market uncertainties. These financing mechanisms were provided through special authorities from Congress and are not typical of a federal agency.

As highlighted in the 2020 BPC case study, *The American Recovery & Reinvestment Act and the Rise of Utility-Scale Solar Photovoltaics: How U.S. Public Policy During the Great Recession Launched a Decade-Long Solar Boom*, by Varun Sivaram, LPO helped finance and demonstrate the first five utility-scale photovoltaic (PV) projects larger than 100 megawatts—an important step in the rapid expansion of this critical clean energy resource in 2011. In the PV case, a new provision of American Recovery and Reinvestment Act of 2009 allowed the Title XVII loan guarantee authority to be used for large-scale demonstrations of "commercially proven technology" and paid for subsidy costs of the loan guarantees, which were a barrier to applying to the program. Part of its success was due to LPO's ability to quickly amass considerable technical and financial expertise to conduct rigorous due diligence of proposed projects. Once private investors had initial experience with LPO-backed solar projects, they were more comfortable funding these projects independently without the need for federal loans or loan guarantees. It was also important that several state (Renewable Portfolio Standards) and federal policies (tax credits) were aligned to help support follow-on deployment of this technology.[xxvii]

However, structural barriers on the front and back end of the loan process have discouraged industry from utilizing the Title XVII program in recent years. Although interest rates for Title XVII are based on Treasury rates, applicants face other costs that discourage participation. These other costs include application fees, third-party advisor fees, credit subsidy costs, and project equity. When a project closes on financing, applicants are responsible for paying the credit subsidy cost (the net present value of the estimated long-term cost to the government of a loan), which can be the largest expense associated with the application process. For other government lending programs, Congress has appropriated funds to lessen or eliminate this cost burden for potential borrowers.[xxviii]

At present, LPO has roughly $40 billion in remaining loan authority, which could be a powerful tool in advancing large-scale demonstration projects. A study from the Energy Futures Initiative found that this remaining loan authority could leverage as much as $100 billion in further investments.[xxix] There have been many attempts to refine LPO by Congress. Bills have been introduced to reduce application and third-party fees, provide more funding for subsidy costs, and change the definition of eligible technologies among many other amendments. The Energy Act of 2020 was successful in changing some eligibility criteria and allows the payment of fees at the point of loan closure. These incremental changes will strengthen LPO and help the office support additional technologies.

Proposed Clean Energy Deployment Administration (CEDA)

The idea of establishing a stable, long-term, well-funded, and business-driven entity within the federal government to leverage greater private-sector investment in clean energy technologies has been circulating for over a decade. In fact, several bipartisan bills were introduced during the 111th Congress in 2009, including the 21st Century Energy Technology Deployment Act (S.949) and the American Clean Energy Leadership Act (S.1462), and more recently in the 116th Congress, Rep. DeGette (D-CO) introduced the Clean Energy Innovation and Deployment Act of 2020 that would have created a new independent agency within DOE called the "Clean Energy Deployment Administration" or CEDA.

A detailed background and description of CEDA can be found in BPC's case study, *The U.S. Clean Energy Deployment Administration: A Business-driven Approach to Leveraging Private Sector Investment in Clean Energy Innovation and Commercialization,* by Dan Reicher.[xxx] As proposed, CEDA would have special authorities to access a diverse set of financing tools and could offer both direct support for large-scale projects—using instruments such as loans, loan guarantees, letters of credit, and insurance products—and indirect support, through securitization and other means of credit enhancement. Additionally, these bills proposed to transfer the authorities of LPO to CEDA. Furthermore, CEDA would have the full faith and credit of the U.S. government. Congress would make an initial appropriation on the order of $10 billion, but CEDA would be self-sustaining thereafter, based on its ability to collect, and reinvest, revenues through fees and insurance. This feature is unlike that of the current LPO or other offices within DOE.

CEDA would operate within DOE, but independently like FERC, under the direction of an administrator and a nine-member board of directors selected by the president, with the Secretary of Energy serving as an ex-officio member. The CEDA administrator would chair the board of directors. CEDA's investment decisions would be guided by a new Energy Technology Advisory Council that would include five members selected by the Secretary of Energy and three members selected by the CEDA board of directors. Among other duties, the Advisory Council would develop a methodology for assessing technologies and would help CEDA identify promising new innovations. Additionally, CEDA would have special hiring authorities. These authorities would not be the same as if it were a private sector corporation, but they would provide considerably more flexibility than is afforded to a typical DOE program office.

The CEDA proposal was voted successfully out of committee on a bipartisan basis but never enacted into law. Notably, the self-financing feature of CEDA reinforced its mandate to focus on the deployment rather than the demonstration of advanced unproven technologies, giving rise to some concerns that the new agency would not have incentives to pursue riskier projects, leaving a key piece of the innovation puzzle unresolved. Additionally, while removed from the typical political influence found in an executive branch agency, CEDA would still be influenced by the Secretary of Energy's selected board members.

Proposed Federal Green Bank, Climate Bank, and Accelerator

Green banks, or climate banks, are institutions currently employed at the subnational level to help provide low-cost capital for clean energy and climate mitigation projects. Green banks are meant to complement existing financial institutions by leveraging private capital that may not have been otherwise directed to clean energy or climate mitigation projects. Today, twenty green banks have been established in the United States, including by fourteen states (California, Colorado, Connecticut, Delaware, Florida, Hawaii, Maryland, Michigan, Nevada, New Jersey, New York, North Carolina, Ohio, and Rhode Island), the District of Columbia, and five cities and counties. The National Renewable Energy Laboratory found as of 2016, "that the most mature green banks in the country, in Connecticut and New York, have collectively invested around $575 billion in total clean energy," – and mobilized billions in private sector investments.[xxxi] Green banks also exist at the national level in the countries of Australia, Japan, Malaysia, Switzerland, and the United Kingdom.

Proposals[xxxii] to establish a national green bank in the United States were included in several bills introduced in Congress between 2014 and 2017; a successor bill, the National Climate Bank Act, was introduced in 2019. The National Green Bank and National Climate bank proposals are quite similar, with minor differences regarding financing capabilities, leadership, initial funding, among other details. In the 117th Congress, Senator Durbin (D-IL) introduced America's Clean Future Fund Act (S.685) to establish a Climate Change Finance Corporation as an independent agency of the government that would act like a national green bank. Another version of the green bank concept, called the Clean Energy and Sustainability Accelerator (the Accelerator), was included in the Climate Leadership and Environmental Action for our Nation's Future Act or the CLEAN Future Act of 2021 (H.R.1512) recently introduced by the House Energy and Commerce Committee. The legislation calls for an initial capitalization of $100 billion for the Accelerator to mobilize public and private investment in climate-friendly energy technologies. The framework released by Senate Democrats for the FY2022 reconciliation package calls for the creation of the Clean Energy Technology Accelerator to fund low-income solar and climate technologies.[xxxiii]

The Accelerator in the House bill would be a nonprofit corporation – i.e., not an agency or instrument of the federal government – and it would have a broad portfolio of tools to help scale and rapidly deploy mature technologies and maximize emissions reductions in the United States. The Accelerator would be able to provide senior, mezzanine, and subordinated debt; credit enhancements, including loan loss reserves and loan guarantees; aggregation and warehousing; equity capital; and any other financial product approved by its board of directors. Because it would be outside the federal government, these financing mechanisms would lack the full faith and credit of the U.S. government.

The Accelerator would focus on aiding market penetration for low- and zero-emission technologies; help ensure that frontline, climate-impacted communities would benefit from the clean energy transition; support the transition of workers impacted by a transition to a low-carbon economy; and support the creation of green banks by states, tribal governments, and communities. Regarding the last responsibility, the Accelerator would have a "start-up division," which would be responsible for

providing technical assistance and start-up funding to states, tribes, and communities to establish green banks.

The governance includes a board of directors with seven members – three appointed by the president and approved by the Senate, as well as four members elected by the three of these appointees. DOE's inspector general and the federal government's comptroller general would have oversight and audit responsibilities, respectively, over the Accelerator. The CEO would be appointed by the board and would be responsible for hiring employees and establishing two divisions of the Accelerator, as well as day-to-day operations.

The green (or climate) bank concept differs from CEDA in that the financing entity takes the form of a mission-driven, private, non-profit corporation, wholly outside any existing government agency such as DOE. Like CEDA, a federal bank would receive an initial appropriation from Congress and would be designed to be self-sustaining thereafter, using returns on previous investments to finance new investments. As with CEDA, this approach has the advantage that it forces the financing entity to be responsive to real-world market conditions—on the other hand (and for the same reason), this self-financing feature could create disincentives to support less proven, high-risk technologies and projects.

Recommendations

To strengthen federal support for the scale-up, technical demonstration, and early commercial deployment of new energy technologies, we offer two recommendations. The first involves building on the capabilities of the existing SCALEUP program at ARPA–E and can be readily implemented in the near term. The SCALEUP program will help address the dearth of support for pre-pilot demonstration efforts. With some minor changes to the new program, along with greater funding for ARPA-E, this program can be strengthened to overcome a key gap in the energy innovation lifecycle. Our second recommendation is to establish a new wholly owned government corporation with a strong relationship to DOE that is specifically focused on large-scale demonstration and early deployment. The entity we propose, called the Energy Demonstration and Finance Corporation (EDFC) for purposes of this discussion, would combine a range of financing tools and independent grant-making authority with the management capabilities of the private sector to take on large, complex, unproven technology demonstration projects and the scale-up of commercially proven energy technologies. By merging several features of the various models summarized in the previous section, this new organization can be a powerful force for accelerating the deployment of technologies needed to achieve ambitious decarbonization goals within the next several decades. Both recommendations are summarized below.

Recommendation #1: Expand funding for the ARPA–E SCALEUP program[xxxiv] and make it into a rolling funding opportunity. Additionally, the SCALEUP program should be opened to applicants regardless of whether they have received ARPA–E funding previously.

ARPA–E's SCALEUP program targets technologies that require scale-up or pre-pilot support to make further progress toward commercialization. In its first iteration, it provided successful applicants with the opportunity to further illustrate the market viability of their technology or project. To date, eligibility has been limited to ARPA–E grantees that have successfully addressed proof-of-concept R&D challenges.

Despite being fairly new, the SCALEUP program is popular with technology developers; with some minor adjustments, we believe it could have a powerful impact. To improve the program and expand access to SCALEUP funding for technology developers, we recommend:

- Increasing overall ARPA–E funding to $1 billion per year, including increased funding for the SCALEUP program specifically.
- Opening the SCALEUP program to some applicants that have not previously received ARPA–E funding.
- Directing ARPA–E to grow the SCALEUP program to at least one-third of the Agency's overall budget, which already has authority to direct up to 50% of its funding to demonstration projects, thus we recommend that ARPA-E grow SCALEUP to, at minimum, 33% of their annual appropriation and never more than 50% should be obligated to demonstration projects. The SCALEUP program should be seen as tightly coupled to an overall increase in ARPA-E's budget and should be carefully designed so it would not cannibalize the Agency's highly effective ongoing programs.

Recommendation #2: Establish a new wholly-owned government corporation equipped to support large-scale demonstration and early deployment of the new technologies needed for decarbonization.

Our concept for a new Energy Demonstration and Finance Corporation (EDFC) draws on the design principles embodied in other proposed energy demonstration and deployment finance institutions. Specifically, it combines the project development capabilities of a new DOE Office of Major Demonstrations, the financing tools of a Clean Energy Deployment Administration (CEDA), and the governance structure of both the (proposed) Energy Technology Corporation (ETC) and the (actual) International Development Finance Corporation (DFC). We envision two core areas of EDFC responsibility: (1) cooperative agreements, grants, and technical support for demonstration projects and (2) financing tools for large-scale, high-risk early project deployments. We emphasize the critically important role of the existing DOE Loan Program and its value in the federal innovation system. LPO should be supported in the near term and as described in recent BPC case study recommendations,[xxxv] can be further improved to drive impact. Further improvements could be to provide LPO additional financing mechanisms such as insurance products, securitization for resale, and other means of secondary market credit enhancement. In the long run, LPO's authorities and capabilities should be incorporated into the EDFC, delivering a more coordinated and effective federal demonstration framework.

Likewise, we see considerable value in the creation of the new Office of Clean Energy Demonstrations. Such an entity would go a long way toward creating a systematic and institutionalized federal approach to large scale demonstration projects. This will help ensure the immense expertise of the Department is leveraged while also ensuring appropriate project management and centralization of activities.

For both the LPO and Office of Clean Energy Demonstrations, we suggest placement in a new EDFC would offer the greatest impact on overall effectiveness, just as it is expected the merger of the Overseas Private Investment Corporation (OPIC)[xxxvi] and the Development Credit Authority (DCA) will result in a stronger DFC. The EDFC should incorporate external private sector technical, financial, regulatory, and project development and management capabilities to better support the private sector in developing projects for which there is little to no experience.

Combining large-scale demonstration and early-deployment support in one organization allows for the sharing of expertise, increased cooperation, as well as a smoother handoff from one stage of innovation to the next. Yet, there is concern that these activities and outlooks are inherently different in their risk tolerance and underwriting and therefore great care will need to be taken to ensure one part does not cannibalize the other. Our recommendations of how to avoid this through key design parameters are summarized below.

Type of institution: We recommend the EDFC be established as a wholly-owned government corporation modeled after the existing DFC, which has a politically proven organizational design and a

"dotted-line" relationship to USAID. Similar to the DFC, the EDFC would have a dotted-line relationship to DOE.

Mission focus: The EDFC would focus on large-scale demonstration and early deployment of advanced energy technologies. Specifically, this would include managing and financing first-of-a-kind and early nth-of-a-kind technology deployments. The EDFC would take a hands-on managerial role in project development and financing, leveraging strong private-sector participation in all its activities including a strong understanding of the regulatory process.

Organizational structure: Initial congressional authorization and appropriations should allow for at least 10 years of operation before reauthorization would be needed.

The EDFC would be governed by an independent board of directors nominated by the president and with the advice and consent of the Senate, as proposed with the ETC and DFC. The board of directors would include both public and private sector individuals. The EDFC CEO would have executive authority over the management of the enterprise and maintain his or her position subject to the confidence of the board; all members of the board would be appointed for rotating 3-year terms with the potential to be reappointed for one additional term.

The EDFC's management structure would be modeled on that of the DFC.[xxxvii] It would include: (1) a chief executive officer appointed by the president and confirmed by the Senate, (2) a chief investment officer appointed by the CEO and subject to approval by the board of directors, and (3) a chief project officer appointed by the CEO and subject to approval by the board of directors. The CEO would have authority to appoint and remove other officers as needed. To avoid and resolve any conflicts of interest the EDFC would adhere to the regulations and guidance of the Office of Government Ethics, just as the DFC does.

Hiring Authority and Compensation: Special hiring authority should be provided to attract individuals with energy sector and regulatory experience and financial and technical skills, including individuals outside the professional civil service system who could be hired on a temporary and time-limited basis at commercially competitive salary levels. The time-limited appointments help ensure employees execute on projects during their tenure, and that the agency is rotating new ideas into the organization. This has been demonstrated to be a critical part of ARPA-E's success as a cutting-edge technology agency.[xxxviii] Further, the EDFC should use success-based incentive pay as well as compensation tied to specific goals of the EDFC. In some cases, this may be timely project completion and in other cases it might be focused on achieving milestones related to new higher risk project demonstration.

Type of financial support provided:
The financial tools available to the EDFC would include contract, grant, and cooperative agreement authorities as well as direct loans, loan guarantees, letters of credit to provide security for a project's

feedstock and/or offtake agreement in the event of default, equity investments, insurance products, securitization for resale, and other means of secondary market credit enhancement.[xxxix] Further, the EDFC could work with private investors and other federal, state, and local government agencies to develop procurement supports and feedstock/offtake agreements, with the ability to blend tools to meet specific project needs. As technologies move to early-stage deployment, the support provided by the EDFC would shift from grants and cooperative agreements toward an increased reliance on loans, loan-guarantees, equity investments, designed to support and attract substantial private financing. Intellectual property developed through grants and cooperative agreements would follow typical federal public law.

Government Funding Required:
We propose that the EDFC be authorized at a total of $60 billion over 10 years, or $6 billion per year, roughly one quarter of the $25 billion per year the AEIC has recommended for federal energy innovation spending.[xl] All funds would be appropriated at one time so the EDFC would not have to go back to Congress for annual appropriations. In this authorization, we recommend $50 billion of contract/grant/cooperative agreement authority to be used on demonstration projects to be executed over the ten-year authorization. The remaining $10 billion should be an authorization of appropriations to pay the subsidy costs of loan, loan guarantees and other project financing tools such as equity and insurance to be used for early deployment. The EDFC, like CEDA, would be "authorized to hold fees collected for financial services rendered and could reuse those fees for further investments," creating a revolving fund.[xli] In 2009, the American Recovery and Reinvestment Act authorized and appropriated $6 billion to pay the subsidy costs of the Section 1705 guaranteed loans; costs which were a known barrier to the success of the program when required to be paid by the borrower.[xlii] The EDFC's $10 billion will cover the same costs and other financing tools. As discussed above, we recommend moving the remaining loan guarantee authority and appropriated credit subsidy and team from DOE's LPO into this new agency to centralize loan making authority.[xliii] The existing authority would be in addition to the new authorities and appropriations provided to the EDFC. The applied programs would not lose any funding. Funding appropriated for the EDFC would be on top of traditional appropriations. The EDFC would be backed by the full faith and credit of the government.

Projects/technologies covered: The EDFC would fund and manage a portfolio of large-scale unproven clean energy demonstration projects and the financing of early deployments with a focus on zero-carbon electricity generation, clean transportation and fuels, industrial decarbonization, and negative emission technologies, along with generation and infrastructure technologies needed to enable a net-zero economy by midcentury. Financing projects would also include manufacturing facilities, if LPO's Advanced Technology Vehicles Manufacturing (ATVM) program is transferred to the EDFC. Projects will be selected based on transparent merit review criteria and strict conflict of interest rules will be enforced to ensure project integrity and to avoid fraud and abuse.

Conclusion

The AEIC has long been an advocate for a stronger, more ambitious, and more strategic national energy innovation agenda. In our 2020 report, we said:

> America's energy innovation ecosystem lacks a mechanism to build, test, and refine large-scale technologies. Many technologies that need demonstration assistance are too big, expensive or risky to go forward by traditional means. A single nuclear plant, or a coal plant that captures and stores carbon, can cost several billion dollars. Large scale projects carrying significant technology risk, when combined with public resources, create high visibility and intense scrutiny—which in turn add the chance of political interference. Simply put, the United States does not have the capacity to rapidly demonstrate large-scale, capital-intensive energy technologies. The nation needs to fix these institutional challenges, or it will not develop the large-scale energy options that our system so urgently needs.[xliv]

The stakes, moreover, are only growing higher. For the United States to meet aggressive mid-century decarbonization commitments, some combination of innovative technologies must be commercially deployed at massive scale within a generation. The recommendations put forward in this report, which are the result of extensive consultation with highly regarded and experienced experts, are not ones we make lightly. The federal government, both the executive and legislative branches, recognize the need to demonstrate new technology, yet no model put forward to-date supports the complex innovation process and the inherent public-private nature of demonstration and deployment. It is abundantly clear that success will be more likely if we expand the tools and public capabilities in addition to financial resources to meet the climate challenge head on. We believe these recommendations provide a strong foundation for moving forward with a successful new strategy. There is no time to lose.

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[i] The 2010 American Energy Innovation Council report, "A business Plan for America's Energy Future," recommended the creation of a New Energy Challenge Program that would create a new independent corporation outside of the federal government to build large-scale pilot projects. This paper is the evolution of the original recommendation and responds to the politcal realities, funding requirements, and new government programs, such as ARPA-E's SCALEUP program.

[ii] AEIC Case Studies are available at: https://bipartisanpolicy.org/report/aeic-scaling-innovation-project/.

[iii] Eric Redman, "A Review of Federal Efforts to Demonstrate Carbon Capture and Storage with Commercial-scale Coal-based Power Plants (2003-2016)," Bipartisan Policy Center and American Energy Innovation Council Scaling Innovation Project, June 2020. Available at: http://americanenergyinnovation.org/wp-content/uploads/2020/06/The-Mixed-Success-of-the-Carbon-Capture-Demonstrations.pdf

[iv] Bloomberg BNA, "DOE Suspends $1 Billion in FutureGen Funds, Killing Carbon Capture Demonstration Project," February 2021. Available at: https://web.archive.org/web/20150212031152/http://www.bna.com/doe-suspends-billion-n17179922773/
[v] Center for Climate and Energy Solutions, Catalyzing Investment with A National Climate Bank: Lessons from Subnational Green Banks, June 2021. Available at: https://www.c2es.org/document/catalyzing-investment-with-a-national-climate-bank-lessons-from-subnational-green-banks/
[vi] IHS Markit and Energy Futures Initiative, Advancing the Landscape of Clean Energy Innovation, February 2019, 37. Available at: https://www.breakthroughenergy.org/reports/advancing-the-landscape/.
[vii] Bipartisan Policy Center. Technology Demonstration Case Study Series. AEIC Scaling Innovation Project. June 2020. Available at: https://bipartisanpolicy.org/report/aeic-scaling-innovation-project/
[viii] Please note that this $35 billion funding value actually represents the five-year total of energy authorizations (both reauthorizations and new authorizations) included in the Energy Act of 2020 and other energy authorizations scattered throughout the omnibus bill.
[ix] U.S. Department of Energy. FY 2022 Congressional Budget Request. May 2021. Available at: https://www.energy.gov/sites/default/files/2021-06/doe-fy2022-budget-volume-3.2-v2.pdf.
[x] Dan Reicher. *The U.S. Clean Energy Deployment Administration: A Business-Driven Approach to Leveraging Private Sector Investment in Clean Energy Innovation and Commercialization*. The AEIC Scaling Innovation Project. June, 2020.
[xi] John Deutch. *An Energy Technology Corporation Will Improve the Federal Government's Efforts to Accelerate Energy Innovation*. The Hamilton Project. Brookings Institution, May 2011.
[xii] Robert Rozansky and David M. Hart. *More and Better: Building and Managing a Federal Energy Demonstration Project Portfolio*. ITIF, May, 2020.
[xiii] US GAO, Federally Created Entities: An Overview of Specific Attributes, Washington, DC, 2009. Available at: https://www.gao.gov/products/gao-10-97
[xiv] Senator Coons, S.2662 - A bill to establish the Industrial Finance Corporation of the United States, August 5. Available at: https://www.coons.senate.gov/news/press-releases/sen-coons-colleagues-seek-to-create-new-domestic-manufacturing-investment-corporation
[xv] Congressional Research Service, "The Quasi Government: Hybrid Organizations with Both Government and Private Sector Legal Characteristics," June 2011, Available at: https://www.everycrsreport.com/reports/RL30533.html.
[xvi] The Oversees Private Investment Corporation was also a wholly owned government corporation.
[xvii] The BUILD Act of 2018, H.R. 302. Available at: https://www.dfc.gov/sites/default/files/2019-08/BILLS-115hr302_BUILDAct2018.pdf
[xviii] U.S. International Development Finance Corporation, "Ahead of President Biden's Leaders Summit on Climate, agency announces new climate action," April 2021. Available at: https://www.dfc.gov/media/press-releases/dfc-announces-call-applications-climate-focused-investment-funds
[xix] US. International Development Finance Corporation, Ethics website. Accessed on August 31, 2021. Available at: https://www.dfc.gov/who-we-are-transparency/ethics
[xx] Robert Rozansky and David M. Hart, "More and Better: Building and Managing a Federal Energy Demonstration Project Portfolio," ITIF, May 2020. Available at: https://itif.org/publications/2020/05/18/more-and-better-building-and-managing-federal-energy-demonstration-project
[xxi] Robert Rozansky and David M. Hart, "More and Better: Building and Managing a Federal Energy Demonstration Project Portfolio," ITIF, May 2020. Available at: https://itif.org/publications/2020/05/18/more-and-better-building-and-managing-federal-energy-demonstration-project
[xxii] H.R.3684 was amended by the Senate with the Bipartisan Infrastructure Deal and passed on August 8, 2021. Available here: https://www.congress.gov/bill/117th-congress/house-bill/3684.
[xxiii] The Synthetic Fuels Corporation is specifically exempted from the Government Corporation Control Act. It was a quasi-independent entity formed after the passage of the Energy Security Act of 1980. The SFC was meant to help

reduce dependence on foreign oil by providing assistance to projects that produced synthetic gas and liquid fuel from coal, shale, and oil sands.

[xxiv] In-Q-Tel is an independent, not-for-profit, non-stock company. It is a strategic investor that works closely with intelligence community (IC) entities and the Department of Defense (DOD). It was authorized by Congress in 1999 and has broad authority on how it expends its funds.

[xxv] National Academies of Sciences, Engineering, and Medicine 2021. *Enhancing Federal Clean Energy Innovation: Proceedings of a Workshop*. Washington, DC: The National Academies Press. https://doi.org/10.17226/25973. Norman Augustine, Email conversation on final draft of BPC Scaling Innovation Report, August 31, 2021.

[xxvi] John Deutch, "An Energy Technology Corporation Will Improve the Federal Government's Efforts to Accelerate Energy Innovation," Brookings Institution, The Hamilton Project, Discussion Paper 2011-05, May 2011. Available at: https://www.brookings.edu/wp-content/uploads/2016/07/05_energy_corporation_deutch_paper.pdf

[xxvii] Varun Sivaram, "The American Recovery & Reinvestment Act and the Rise of Utility-scale Solar Photovoltaics: How U.S. Public Policy during the Great Recession Launched a Decade-long Solar Boom," Bipartisan Policy Center and American Energy Innovation Council Scaling Innovation Project, June 2020. Available at: http://americanenergyinnovation.org/wp-content/uploads/2020/06/The-Successful-Demonstration-of-Utility-Scale-PV.pdf

[xxviii] BPC, "New Opportunities to Spur Economic Recovery: Bolstering Successful Financing Tools at DOE's Loan Programs Office," April 2020. Available at: https://bipartisanpolicy.org/blog/new-opportunities-to-spur-economic-recovery-bolstering-successful-financing-tools-at-does-loan-programs-office/

[xxix] "Leveraging the DOE Loan Programs," Energy Futures Initiative, March 2018. Available at: https://static1.squarespace.com/static/58ec123cb3db2bd94e057628/t/5a9815ec652dea1afc928a23/1519916525040/EFI+LPO+Report+03.01.2018.pdf

[xxx] Dan Reicher, "The U.S. Clean Energy Deployment Administration: A Business-driven Approach to Leveraging Private Sector Investment in Clean Energy Innovation and Commercialization," Bipartisan Policy Center and American Energy Innovation Council Scaling Innovation Project, June 2020. Available at: http://americanenergyinnovation.org/wp-content/uploads/2020/06/Looking-Forward-with-a-Clean-Energy-Deployment-Administration.pdf

[xxxi] "Green Banks," National Renewable Energy Laboratory, 2020. Available at: https://www.nrel.gov/state-local-tribal/basics-green-banks.html#:~:text=Green%20Banks%20help%20secure%20low,achieving%20cost%2Dcompetitive%20solar%20energy.

[xxxii] Different versions of green bank legislation have been introduced in Congress. Another bill of interest is Senator Durbin's, America's Clean Future Fund Act (S. 685), which includes the Climate Change Finance Corporation, another version of a green bank.

[xxxiii] Senate Democrats, "FY2022 Budget Resolution Agreement Framework," August 9, 2021. Available at: https://www.democrats.senate.gov/imo/media/doc/MEMORANDUM%20for%20Democratic%20Senators%20-%20FY2022%20Budget%20Resolution.pdf?utm_medium=email&utm_source=FYI&dm_i=1ZJN,7HN3Y,3CTLR0,UGE19,1

[xxxiv] "SCALEUP," ARPA-E. Available at: https://arpa-e.energy.gov/scaleup

[xxxv] Varun Sivaram, "The American Recovery & Reinvestment Act and the Rise of Utility-scale Solar Photovoltaics: How U.S. Public Policy during the Great Recession Launched a Decade-long Solar Boom," Bipartisan Policy Center and American Energy Innovation Council Scaling Innovation Project, June 2020. Available at: http://americanenergyinnovation.org/wp-content/uploads/2020/06/The-Successful-Demonstration-of-Utility-Scale-PV.pdf

[xxxvi] The Oversees Private Investment Corporation was also a wholly owned government corporation.

[xxvi] The BUILD Act of 2018, H.R. 302. Available at: https://www.dfc.gov/sites/default/files/2019-08/BILLS-115hr302_BUILDAct2018.pdf

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

[xxxix] Dan Reicher, "The U.S. Clean Energy Deployment Administration: A Business-driven Approach to Leveraging Private Sector Investment in Clean Energy Innovation and Commercialization," Bipartisan Policy Center and American Energy Innovation Council Scaling Innovation Project, June 2020. Available at: http://americanenergyinnovation.org/wp-content/uploads/2020/06/Looking-Forward-with-a-Clean-Energy-Deployment-Administration.pdf

[xl] "Energy Innovation: Developing the Technologies for Decarbonization," Bipartisan Policy Center and the American Energy Innovation Council, Dec. 2020. Available at: http://americanenergyinnovation.org/wp-content/uploads/2020/12/BPC_AEIC-Policy-Memo_RV4.pdf

[xli] Dan Reicher, "The U.S. Clean Energy Deployment Administration: A Business-driven Approach to Leveraging Private Sector Investment in Clean Energy Innovation and Commercialization," Bipartisan Policy Center and American Energy Innovation Council Scaling Innovation Project, June 2020. Available at: http://americanenergyinnovation.org/wp-content/uploads/2020/06/Looking-Forward-with-a-Clean-Energy-Deployment-Administration.pdf

[xlii] These costs include application fees, third-party advisor fees, credit subsidy costs, and project equity. When a project closes on financing, applicants are responsible for paying the credit subsidy cost (the net present value of the estimated long-term cost to the government of a loan), which can be the largest expense associated with the application process. For other government lending programs, Congress has appropriated funds to lessen or eliminate this cost burden for potential borrowers. BPC, "New Opportunities to Spur Economic Recovery: Bolstering Successful Financing Tools at DOE's Loan Programs Office," April 2020. Available at: https://bipartisanpolicy.org/blog/new-opportunities-to-spur-economic-recovery-bolstering-successful-financing-tools-at-does-loan-programs-office/

[xliii] Addison Stark, "Establish a Clean Energy Deployment Administration," Bipartisan Policy Center, April 29, 2020. Available at: https://bipartisanpolicy.org/blog/establish-a-clean-energy-deployment-administration/

[xliv] American Energy Innovation Council, "Energy Innovation: Supporting the Full Innovation Lifecycle," Bipartisan Policy Center and American Energy Innovation Council Scaling Innovation Project, February 2020. Available at: http://americanenergyinnovation.org/2020/02/energy-innovation-supporting-the-full-innovation-lifecycle/