PRIORITY INNOVATION POLICIES

Stimulating Entrepreneurship

Overview

At present, the United States underinvests in clean energy technologies. For the earliest stage of clean energy research and development (R&D), conducted primarily at universities and the Department of Energy's (DOE's) National Laboratories, the federal government allocates about $7 billion in annual funding. For mature technologies like wind and solar power, U.S. capital markets currently deliver about $60 billion in annual investment. Both of these public and private investments should be 3–10 times greater (depending on the model used) in order to eliminate net greenhouse gas (GHG) emissions by mid-century.

The level of underinvestment is even more acute during the phase between R&D and commercial deployment. Between 2009 and 2018, venture-capital funds only invested about $250 million each year in about 125 early-stage (Seed and Series A) energy and power startups.[1] By comparison, during that same period, overall early-stage venture investment rose from $4 billion to more than $20 billion.[2] Since venture capital is often a necessary condition for the ultimate success of a technologically innovative, capital-intensive company, this gap keeps many clean energy entrepreneurs from ever leaving the starting gate.

In order to both stimulate and sustain the development of clean energy technologies at an appropriately ambitious speed and scale, federal policies must be designed to support entrepreneurs all the way from company formation to commercial success. This includes recruiting talented teams to clean energy entrepreneurship, directing more public funding to pre-venture startups, designing effective incentives for venture capital and later-stage investment, and creating large demand-side market signals for novel clean energy technologies.

Policy interventions include:

1. **Recruiting talented scientists** to clean energy entrepreneurship, prioritizing Black, Indigenous, and Latino communities as well as low-income and disabled populations.
2. **Increasing the scale and impact of pre-venture funding.**
3. **Providing incentives for equity investors** in clean energy technologies.
4. **Guaranteeing demand** for clean energy technologies.
5. **Maximizing the climate impact** of federal funding.

1. https://www.cleantech.com/

2. https://www.pwc.com/us/en/industries/technology/moneytree/explorer.html#/

Legislative Principles and Policy Recommendations

1. Increase funding to recruit talented scientists to clean energy entrepreneurship.

On-ramps to clean energy entrepreneurship—including modest incentive prizes, incubator networks, lab-embedded entrepreneurship programs, and customer discovery training—are all proven to draw and focus entrepreneurial talent on new technologies with high potential impact.

Entrepreneurship is an inherently risky path. Most startups fail—and that risk is even greater for a new technology that depends on an innovative scientific discovery working out at scale. Consequently, a number of different policy approaches are necessary in order to maximize success for clean energy innovation.

Effective clean energy entrepreneurship-incentive programs tend to recruit small teams rather than individuals, target innovations at the pre-company stage, provide relatively small grants ($50,000–$250,000) over 1–2 years, and offer value beyond money—including lab equipment, industry knowledge networks, and customer-discovery training. The goal of these programs is to give teams enough time, expertise, and community support to make an informed decision about founding a company and dedicating a decade or more to its growth. These programs should also provide an equitable platform for Black, Indigenous, and Latino researchers to receive funding and training to ensure that clean technologies represent the diversity of the U.S.

As such, DOE should revitalize and expand the following programs:

The Cleantech University Prize, funded and administered by DOE between 2011–2018, incentivized university students across the country to pitch clean energy startup ideas in eight regional competitions, feeding into a national competition with a $100,000 grand prize. DOE estimates that participants in these competitions have gone on to form more than 200 ventures, create more than 120 jobs, and raise over $120 million in follow-on funding. A relatively modest annual commitment of federal funds (<$1 million/year) would revitalize this high-yield recruitment strategy.

The Incubatenergy Network, initially funded by DOE and now run by the Electric Power Research Institute (EPRI), is a network of over 20 competitive clean energy accelerator and incubator programs located primarily in the United States. Each of these programs provides an on-ramp for entrepreneurial teams to learn from peers and industry experts at a very early stage, and each is typically focused on a particular region or industry. DOE's Office of Energy Efficiency and Renewable Energy (EERE) Technology-to-Market budget should be sustained at an annual level of at least $20 million in order to launch and grow new programs with similar potential.

Energy I-Corps is an entrepreneurial boot camp for researchers who work at DOE's National Laboratories. Teams of lab scientists are paired with industry mentors for a two-month intensive regimen in which they define the value proposition of their technology, conduct numerous customer-discovery interviews, and assess viable market pathways. At the end of this program, teams make a "go/no-go" decision on whether to form a company dedicated to the commercialization of the lab technology. This program should be expanded to include DOE-funded teams at universities and startups as well, with an annual funding level comparable to the $30 million I-Corps program at the National Science Foundation (NSF).

DOE has also funded Lab-Embedded Entrepreneurship Programs at three of its National Laboratories to "provide an institutional home for innovative postdoctoral researchers to build their research into products and train to be entrepreneurs." These three programs—Cyclotron Road at Berkeley Lab, Chain Reaction Innovations at Argonne National Laboratory, and Innovation Crossroads at Oak Ridge National Laboratory—allow first-time entrepreneurs with deep technical expertise to access extraordinarily high-value equipment, mentors, and training over the course of two years in residence. These teams and technologies tend to emerge in an excellent position to form companies and compete for grants and investment. Sustained federal funding at $50 million per year would support a new annual national cohort of 100 fellows at an expanded number of DOE laboratories and universities.

2. Increase the scale and impact of early-stage non-dilutive funding at the agency level as well as the program level.

Once an entrepreneurial team has formed a new company to bring a new clean energy technology to the marketplace, it is unlikely that venture capital (VC) investors will be ready to step in immediately. Instead, it typically takes at least another few years to reduce technological risk, develop a marketable product, and demonstrate customer interest—let alone generate revenue.

Public funding is essential at this pre-venture stage to provide enough "runway" (or time before insolvency) for the startup to meet the technical and market milestones that VCs will ultimately demand. Effective pre-venture funding programs tend to target innovative companies at the earliest stage (1–3 years old), provide non-dilutive grants ($250,000–$2,000,000) over 2–3 years, and offer value beyond money—including lab services, industry knowledge networks, and technology-to-market assistance.

Consequently, DOE should optimize and expand the following programs:

Most pre-venture funding for clean energy startups comes from long-standing programs within EERE and other applied research offices. The Advanced Research Projects Agency–Energy (ARPA-E), an independent component of DOE focused on high-risk/high-return research across industries, tends to award a greater proportion of its program dollars to early-stage companies compared to universities, national labs, and larger companies. Ambitious DOE R&D funding goals are described in detail elsewhere in this playbook.

The Small Business Innovation Research (SBIR) program is the federal government's largest annual funding opportunity available exclusively to startups and small businesses commercializing new technologies. It awarded over $3.1 billon to nearly 3,600 firms in FY2018—including about $300 million awarded to approximately 400 firms by DOE. This funding is non-dilutive (the government receives no direct financial upside) and is typically divided into an initial Phase I ($150,000–225,000 over 6–12 months) and a subsequent Phase II ($750,000–1,000,000 over 2 years). A number of operational reforms would increase the commercial and climate impact of the SBIR program at DOE.

Sunshot Incubator was a program within EERE focused exclusively on early-stage startups working to "develop and launch transformative photovoltaic, concentrating solar power, grid integration, system installation, and soft costs products and service." Participating companies achieved an impressive level of success in obtaining follow-on investment. Sunshot Incubator demonstrated that similar startup-focused programs in other technology areas can be successfully sustained at $15 million per year.

American-Made Challenges represent a relatively new model within EERE: they move clean energy entrepreneurs through a rapid tournament of three sequential prize competitions, from planning ($50,000) to proof of concept ($200,000) to pilot partnership ($500,000). Beginning with solar technologies, this model has now been used to generate startup activity in manufacturing efficiency, wave power, and other promising arenas. DOE should devote at least $10 million per year to establishing American-Made Challenges across EERE and other applied research offices.

The Small Business Vouchers program was an elegant way to incentivize both small startups and large national labs to collaborate on commercially promising research. By running a single competition where small businesses proposed their own technical projects, DOE took on the burden of finding the right experts at the right labs for the most promising partnerships and ensured that collaboration agreements were easy and quick to execute. Since these collaborations were worth $50,000–$300,000 at no cost to the small business, there was a strong incentive to participate. The program should be revitalized and extended across other DOE offices at an annual funding level of at least $30 million.

3. Provide incentives for equity investors in clean energy technologies, including match funding for venture capital and well-designed incentives for later-stage private equity.

The job of a VC fund is to invest someone else's money (usually an institutional investor, less often a high-net-worth individual) in a portfolio of young companies that deliver well-above-market returns in less than ten years. Most VCs fail to do so even when they are investing only in potential software "unicorns" or biopharma blockbusters. Clean energy innovation is even riskier, and it is unreasonable to expect that such investors will devote more resources to it without public incentives that increase the likelihood of adequate returns.

Designing effective public incentives for private equity is difficult and requires aligning at least three separate interests. The primary interests of the entrepreneur are speed and simplicity. For them, an overly complex fundraising process will not be worth the distraction. By contrast, the primary interest of the venture investor is realizing outsized returns. And the primary interest of policymakers and taxpayers is realizing public value, whether measured in terms of economic growth, job creation, climate benefits, or other shared goals.

As such, the federal government should work to optimize and expand the following programs:

Public/private matching funds: Some agencies have augmented their SBIR programs with a "Phase IIB" that lures venture investors with matching federal dollars. For example, NSF will provide a 1:2 match (up to $500,000) with private sector investment (up to $1 million) in startups that have graduated from Phase II. The National Cancer Institute, part of the National Institutes of Health (NIH), has a similar Phase IIB bridge program. Unfortunately, it is still rare to find federal programs like these that successfully draw venture capital into innovative technology companies. DOE should implement its own Phase IIB program to help remedy this.

Small Business Investment Companies (SBICs): SBICs are privately managed investment funds backed by a loan guarantee from the U.S. Small Business Administration (SBA). The SBA's contribution is typically 2:1 for each dollar of private capital raised by the fund, up to $175 million. Today there are about 300 SBIC funds investing some $30 billion in small businesses, but these tend to be relatively mature companies with low technology risk. Because SBIC funds are required to make semiannual interest and fee payments back to the SBA, they tend to focus their investments on mid- and later-stage small businesses that have positive cash flow. Past attempts to encourage SBIC funds to invest in more innovative early-stage startups were short-lived, suggesting that more significant design changes are necessary.

Opportunity Zones: The 2017 tax bill included major incentives to invest in low-income communities, which governors delineate within each state as Opportunity Zones. Investment funds that hold at least 90 percent of their assets in such Opportunity Zones can offer significant tax incentives to investors, including a temporary tax deferral and up to 15 percent tax exclusion for prior capital gains, as well as a permanent tax exclusion for new capital gains held for at least ten years. While these new Opportunity Funds are attracting significant investment, most of these dollars will flow to relatively predictable and low-risk real estate projects rather than innovative new companies. Future tax incentives should include more support for private sector investment in innovative clean energy technology companies as well.

4. Guarantee demand by creating "demand pull" mechanisms for upstream investors and entrepreneurs on par with the revenues expected of IPO-eligible software and biotechnology companies.

The policies described thus far—indeed, most government policies to promote innovation—all serve to "push" a new technology from R&D project to startup to mature company by subsidizing R&D and investment along the way. The most powerful incentive for any entrepreneur or investor, however, is the "pull" of paying customers and the value this demand creates. Few entrepreneurs or investors realize significant returns without an "exit" (either an initial public offering (IPO) or an acquisition by another company), and such events do not occur until the company can demonstrate—or at least plausibly predict—sizable demand for its product.

A software company can acquire customers, whether via millions of online consumers or large enterprise contracts, relatively quickly. A biopharma company takes longer to bring a new product to market, but each time it successfully passes an FDA trial, it is measurably closer to charging premium prices for a patent-protected innovation with few substitutes. A clean energy company, on the other hand, may be developing a deep technological breakthrough that, even if successful, will still be competing with incumbent commodities such as wholesale electricity or fossil hydrocarbons.

Therefore, it is unfortunate but not surprising that clean energy startups tend to deliver much lower returns than software and biopharma startups. Without massive revenue opportunities, most venture capital flows elsewhere.

Given this reality, federal policy can play a critical role in establishing very large market signals for clean energy investors and entrepreneurs, as well as creating an expectation of revenues on par with those achieved by IPO-eligible software and biotechnology companies. Such "demand pull" mechanisms can take the form of large incentive prizes, government-orchestrated buyer consortia, and milestone-based payments with government playing the role of first customer.

Successful government-funded demand-pull mechanisms achieve three core goals. First, they fulfill an essential federal-agency mission. Second, they stimulate a self-sufficient commercial industry. Third, they ultimately save taxpayer dollars.

The following demand-based approaches have tremendous potential as applied to climate and energy technology challenges, both within DOE (e.g., storage, buildings, generation) and among other federal agencies (e.g., agriculture, aviation, transportation).

Incentive prizes: In the short run, a well-designed incentive prize can catalyze private sector investment into competitor teams, sometimes exceeding the size of the prize purse. In the long run, the winners can stimulate massive corporate and investor interest in an entirely new industry by demonstrating the underappreciated readiness of a new technology. Canonical examples include the government-funded DARPA Grand Challenge for autonomous vehicles and the philanthropy-funded Ansari XPRIZE for private spacecraft. Recent clean energy technology prizes have been privately funded, including the Google Little Box Challenge for small-scale inverters and the Carbon XPRIZE for carbon capture and utilization. DOE and other agencies already have authority from Congress for prizes up to $50 million and they should exercise this authority much more frequently in promising technology arenas.

Buyer consortia: In some cases, even non-binding letters of interest from enough large potential buyers can catalyze technology innovation. With its Rooftop Unit Challenge, DOE partnered with Walmart, Target, and other large retailers to stimulate the market for 10-ton capacity commercial air conditioners that would dramatically outperform then-available models on cost and efficiency. The General Services Administration (GSA) provided a real-world warehouse test site, and the Pacific Northwest National Laboratory (PNNL) evaluated designs from five manufacturers, with the winning model delivering 26 percent energy savings. Similarly, the Wireless Metering Challenge brought more than 200 commercial building partners to spur the development of wireless sub-meters that cost less than $100 and meet DOE performance specifications. DOE should expand buyer consortia to other technology arenas beyond commercial building energy efficiency.

Government as first customer: At a large enough scale, the federal government can use milestone-based R&D awards and its own purchasing power to foster competition among entrepreneurial companies and ultimately create a new industry. For example, beginning in 2006, NASA pioneered a new approach to government procurement through its Commercial Orbital Transportation Services (COTS) program. NASA paid competing companies only when they achieved clear technology milestones on the path to developing spacecraft that could service the International Space Station, with the promise of even higher-value launch contracts for successful participants. This stimulated a flood of private sector investment and saved taxpayers nearly $4 billion compared with traditional single-source procurement practices. The United States had essentially no commercial space industry when NASA began this experiment. Today, SpaceX and its U.S. competitors lead the world. Similar potential exists in other new industries, such as advanced nuclear power and low-carbon aviation, where DOE can provide milestone-based R&D funding followed by milestone-based procurement agreements from NASA and DOD.

5. Conduct robust analysis and leverage existing tools to maximize the climate impact of federal funding.

It is currently extremely difficult to evaluate the emissions-reducing impact of a given technology even retrospectively, after analyzing decades of data. It is nearly impossible to do it predictively, when the product is in its infancy.

As a general matter, however, it is possible for investors and program managers to make an educated guess about the emissions-reducing potential of a given technology based on a model of how it could change the business-as-usual trajectory within a given industry. For example, Breakthrough Energy Ventures restricts its investment portfolio to "technologies with the potential to reduce at least half a gigaton of GHGs every year, or about 1 percent of projected 2050 global emissions."

One promising methodology for agency portfolio managers is CRANE (Carbon Reduction Assessment: New Enterprises), an open-source software tool that aims to standardize and streamline climate impact assessment of early-stage companies with innovative technologies. By modeling the net impact of a given product at an estimated future deployment at scale, CRANE calculates that technology's emissions reduction potential over time. (See detailed methodology here.)

Such models cannot predict whether a particular venture or technology will succeed or fail. But they can provide insight on whether an individual company or portfolio of companies could conceivably deliver significant emissions-reducing impact per dollar of federal funding.

The Impact of Stimulating Entrepreneurship

Already, with well-designed programs like the ones below, federal funding of clean energy startups has achieved remarkable return on investment. If the funding increases and program improvements recommended above were implemented, we would expect at least a doubling of clean energy startups across technology domains, with outsized commercial and climate impact in the long run.

Sunshot Incubator: Launched in 2007 by DOE, the Sunshot Incubator program provided early-stage funding and other support for startups with the potential to “significantly lower the total installed cost of solar energy systems.” Within a 10-year period, DOE provided $138 million funding for over 100 companies, who then went on to raise more than $3.1 billion in venture capital and private equity investment. While it is difficult to establish initial government support as the sole determinant of subsequent capital investment, this ratio of nearly 22:1 in private-to-public dollars is impressive for a federal program.

Small Business Vouchers: DOE’s Small Business Vouchers program subsidized cooperative research agreements between National Labs and over 100 competitively selected small businesses, with access to lab staff and facilities valued at $50,000–$300,000 per award. An independent evaluation of the program found that the proportion of participants advancing their product’s technology-readiness level (81 percent) was significantly greater than among non-participants (43 percent).

Small Business Innovation Research: One of the most promising methodologies for measuring economic impact comes from DOE’s Small Business Innovation Research (SBIR) program, which grants technology commercialization awards to energy-related startups and small businesses. Using data on more than 4,500 firms, one study compared applicants ranked just above and below the award cutoff, and found that Phase 1 awards ($150,000) are associated with increases of 250 percent in patenting activity, 19 percent in employment, 29 percent in payroll, 11 percent in wages, and 15 percent in revenue.

ARPA-E: As of early 2017, 580 ARPA-E project teams, which previously received a total of about $1.5 billion from the agency, had formed 56 new companies and raised more than $1.8 billion in private sector follow-on capital. An independent study found that ARPA-E-funded companies raised more money on average than other clean energy startups, with 5x better odds of being in the top 10 percent of private sector fundraising and triple the odds of receiving scale-up funding from other government agencies.