THIRD WAY

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Can U.S. Leadership Bridge the Clean Energy Global Demonstration Gap?

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To get to net-zero emissions by 2050 – or really, any time – innovative, complex, large-scale technologies will have to be adopted globally. New kinds of power plants, whether nuclear, renewable, or fossil energy with carbon capture. New kinds of industrial plants, like clean steel or chemicals. New kinds of energy storage, with enough capacity to power whole cities for weeks at a time. And more.

Small-scale technologies alone just won't cut it, not in a world where billions of people need ample, reliable energy to live fulfilling lives, and a billion or so more still do not have access to energy just to meet their basic needs.

But big innovations are hard. Many fail to get off the ground, and those that do frequently take decades to achieve widespread adoption. The reasons are manifold, but the biggest is that such innovations are risky. Few companies want to bet billions of dollars knowing that they may well fail. Worse, even if they succeed, others may reap the benefits.

That means governments have to bear the risks if key clean energy technologies are to cross the so-called demonstration "valley of death." And they need to do so quickly. To do large-scale demonstrations well enough to convince skeptical buyers typically takes several years to a decade. Even in the best of circumstances, global adoption takes at least a couple of decades more, due to residual uncertainty and the long lifespans of existing capital equipment. 2050, from this perspective, is just around the corner. Urgent action is needed if large-scale, complex innovations are going to contribute to solving the climate crisis by then.

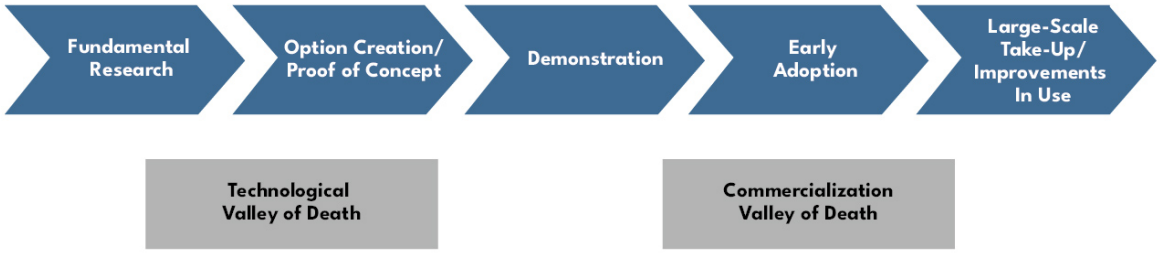
The good news is that governments have begun to step up. The United States appropriated upwards of $25 billion for demonstration projects over the past year. The European Union is expecting a large increase in its Innovation Fund, which is slated to go toward demonstrations. China, Japan, South Korea, and others have announced numerous new projects in fields like hydrogen production; carbon capture, utilization, and storage (CCUS); and industrial decarbonization.

But it's not yet enough. The International Energy Agency's (IEA) Net Zero Emissions by 2050 scenario finds that $90 billion in public funding must be invested in large-scale demonstration projects before the end of the 2020s.

In June, President Biden issued a challenge, calling on the world to hit the IEA's target. This post briefly reviews recent progress and explores how the challenge can be met through a mix of international competition and cooperation, emphasizing the link between cooperation and adoption. First, we provide an introduction to demonstration.

Demonstration: A Short Introduction

Demonstration is a key stage in the innovation process. The International Energy Agency (IEA) defines it as the "operation of a prototype … at or near commercial scale with the purpose of providing technical, economic and environmental information." If we think of innovation as a process that begins with scientific research and ends with a marketable product, demonstration is roughly in the middle. [see figure] Without the information that demonstration projects supply, investors who might bring a product to market will lack confidence that they can make money.



Source: Robert Rozansky and David Hart, "More and Better: Building and Managing a Federal Energy Demonstration Project Portfolio." May 2020.

Demonstration is particularly important and particularly difficult to finance for complex, large-scale, capital-intensive technologies. By definition, the money at stake is bigger. But the technical stakes are higher, too, because complexity frequently leads to surprises when such technologies are taken out of the lab, scaled up, and put into the real world. While power plants and factories might not be quite as complex as spaceships, the surprises that led NASA to scrub planned launches of its new Artemis rocket are similar in kind to those that may arise in clean energy demonstration projects.

These risks deter all but the most determined and deep-pocketed firms. Indeed, without public funding, progress is slow at best. A comprehensive review of demonstration projects across eight sectors over the last half century by Gregory Nemet of the University of Wisconsin and his colleagues found that public funding was often essential to get major clean energy innovations across the demonstration "valley of death." But it can be done, as the histories of nuclear power and solar power show.

Recent Progress

United States

The U.S. government has provided funding for demonstration projects in short bursts over the years. However, until the passage of the Infrastructure Investment and Jobs Act (IIJA) in late 2021, no new federal money had gone toward such projects for more than a decade.

The IIJA created a new Office of Clean Energy Demonstrations (OCED) within the U.S. Department of Energy (DOE) and gave it more than $20 billion to invest over a five-year period. OCED's key responsibilities include $8 billion for regional clean hydrogen hubs, $3.5 billion for carbon capture pilots and demonstrations, and over $3 billion for advanced nuclear reactors. Additional funding for demonstration projects, such as $3.5 billion for carbon removal, was assigned by the IIJA to other DOE offices. The Inflation Reduction Act, which passed in August 2022, added to the total, giving OCED almost $6 billion more for industrial decarbonization projects.

Unlike most U.S. federal programs, the new energy demonstration portfolio is funded up front for multiple years. Most federal funding must be matched by private investments. This approach should allow DOE to manage the funds wisely and avoid common pitfalls that plague demonstration projects, such as scaling up too quickly or failing to coordinate with the private sector. It also gives certainty to private partners in these projects that election results will not lead to abrupt policy shifts. And Congress's decisive action gave President Biden the confidence to issue his challenge to the world.

European Union

The European Union first established a demonstration program using proceeds from its carbon pricing system in 2009. That program was reformed, expanded by the European Green Deal, and relaunched as the Innovation Fund in 2020. Initially budgeted at €10 billion, the Innovation Fund was further expanded in 2022 to an estimated total of €38 billion through 2030, depending on actual carbon prices.

The Innovation Fund targets technologies for energy-intensive industries, CCUS, renewable energy, and energy storage. Like the U.S. demonstration program, project costs are shared with the private sector, although applicants may also draw on public programs other than the Innovation Fund as well. The first funding round supported seven large-scale projects with just over €1 billion. Projects include bioenergy power generation with CCS, steel-making with green hydrogen, and low-carbon cement production. A second funding round with up to 17 projects and €1.8 billion is expected to be completed by the end of the year, and a third round of €3 billion has been announced.

National governments in Europe have supported large-scale energy demonstration projects as well. Germany, for instance, has a $9 billion hydrogen program, which includes some demonstration projects.

Asia, Latin America, and Africa

Guided by the 14th Five Year Plan, China is actively investing in demonstration projects like CCUS, hydrogen, and industrial decarbonization. In 2021, for instance, Sinopec announced the Xinjiang Kuqa Green Hydrogen Pilot Project, which will produce 20,000 tons of green hydrogen annually. The firm also announced in 2022 that it completed construction of the first megaton CCS plant in China, while CNOOC launched the first offshore CCS project a year earlier. China is also one of only a handful of countries planning small modular nuclear reactor (SMR) projects, with four demonstration projects underway, including two floating nuclear reactors.

Japan announced its Green Innovation Fund in 2020, which allocates roughly $19 billion to support key clean energy technologies. Twelve projects have received support from this fund to date. Technology focus areas include next-generation shipping, hydrogen production and utilization in steelmaking, floating offshore wind power, and low-carbon ammonia fuel. Outside the Green

Innovation Fund, Toshiba in 2020 began operation of the first large-scale facility for capturing CO2 from a biomass power plant, while Japan's largest hydrogen plant powered by offshore wind is set to open in 2024.

Other countries in Asia are also investing in demonstration projects. South Korea has three green hydrogen projects planned for this decade. Pakistan, Morocco, India, Oman, and the Philippines also have green hydrogen projects under development, and several CCUS facilities are being built in Indonesia. In Latin America and Africa, green hydrogen projects have been announced in Mexico, Chile, Uruguay, Colombia, Brazil, South Africa, and Namibia. A $10 billion project announced in Namibia is a collaborative endeavor with Germany that has a budget nearly as large as Namibia's annual GDP.

Meeting the Challenge and Linking Demonstration to Global Adoption

These diverse announcements of new demonstration projects and programs are very encouraging. But more must be done to hit IEA's $90 billion target. To some extent, the momentum will be maintained by competition among nations. Many see demonstration projects as a gateway to competitive advantage in industries of the future like hydrogen.

Yet, international cooperation must also play a central part if the climate is to fully benefit from demonstrations. Global adoption of demonstrated technologies is the ultimate goal. It will move more quickly and with less friction if the Global South, which will dominate the future growth of the world's energy system, partner to build in demonstration projects. The U.S. government can take several steps to enable such partnerships and encourage other governments to do the same, in parallel with its call to increase spending internationally. Such cooperation should be win-win deals for all partners.

The IEA analysis makes the argument for cooperation with emerging economies as well. Cooperative demonstration projects contribute to innovation networks internationally, providing financial support, equipment, and know-how. Demonstrating technologies such as hydrogen production and use or new nuclear plant designs in different environments will make them more robust and provide valuable information to their developers. This has a double benefit: the local economy benefits from the construction and operation of the demonstration project, and the technology-providing partner can take that knowledge home and continue to iterate on the technology, producing even more opportunities for collaboration and innovation. In the cases where the US provides materials, labor, and expertise, this enables domestic companies and innovators to tap into large global markets for emerging technologies. According to a new report from the Boston Consulting Group, the US could play a key role in exporting long-duration energy storage (LDES) equipment and technologies to emerging economies like India. A bilateral and equal

agreement to demonstrate these technologies and share knowledge and resources can offer the US a customer and partner in the manufacture of nascent LDES technologies.

The U.S. government has several mechanisms to finance clean energy projects in emerging economies. For instance, the US Agency for International Development and the Development Finance Corporation both have catalyzed the investment of millions of dollars into building clean energy all over the world. Notably, however, these programs lack a unique technology innovation focus (though USAID's Water and Energy for Food grand challenge does promote business model, finance, and end-use innovation).

A U.S. initiative to build clean energy demonstration projects in cooperation with international partners in the Global South would help cement its position as a clean energy technology leader worldwide, strengthen its competitive standing, and accelerate global emissions reductions in hard-to-abate sectors.