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Closing the Energy-Demonstration Gap

A regional approach to demonstrating the commercial potential of major new energy technologies would open up new opportunities for accelerating innovation.

The high costs and risks of demonstrating new clean energy technologies at commercial scale are major obstacles in the transition to a low-carbon energy economy. To overcome this barrier, we propose a new, decentralized strategy for energy technology scale-up, demonstration, and early adoption, with a greater role for states and regions and a new kind of partnership between the federal government, the states, and private innovators and investors.

The challenges of scaling up new technologies are well known. What works in the laboratory or in a small-scale prototype often doesn't work nearly as well at full commercial scale, at least initially. Building, operating, and debugging full-scale prototypes invariably reveals new problems that must be solved. Moreover, new technologies are hardly ever deployed in isolation. More often, they must be incorporated into a pre-existing technological and organizational system, and the task of integration is often very demanding. Often, too, complementary technologies such as new manufacturing processes and logistical systems must be developed and scaled up in parallel.

Before a new technology can be commercialized, all of these new elements must be demonstrated in as close to a market setting as possible. The primary objective of a demonstration project is to provide technology developers, investors, and users with information about the costs, reliability, and safety of the new technology in circumstances that approximate actual conditions of use. A successful demonstration resolves technological, regulatory, and business risks to levels that would allow the first few commercial projects to proceed with private investment. In fact, more than one such project may be required, and it is probably more accurate to think in terms of a demonstration "phase," rather than a single demonstration project.

For many new energy technologies, the challenges of scale-up and demonstration are compounded by the large scale of the projects. For technologies like advanced nuclear reactors and carbon capture and sequestration systems, investments of a billion dollars or more may be required, even for a single demonstration project. The cost of demonstrating new manufacturing processes for biofuels or for distributed energy technologies such as photovoltaic modules may also be in this range. The sheer size of such projects is a deterrent to private investors, and this is exacerbated by the uncertainties involved – not only about the technical and economic performance of the technologies themselves, but also about the new environmental, health, and safety standards and regulations that typically must be developed in parallel, as well as the future market price of competing fuels, and the future regulatory price on carbon emissions. Conventional private financing approaches are poorly suited to this task: venture equity funds are

structured to finance high-risk technology development activities but not major, billion-dollar-scale projects, while more traditional project finance investors are well structured to finance assets of this size, but not to take on technology scale-up risk.

In the past, these activities have been financed and sometimes also implemented by the federal government. But the federal role in energy technology demonstrations has had a checkered history. Projects have frequently suffered from administrative and technological failures and have been dogged by political controversies. Today there is no agreed framework for federal involvement in these activities. This is one of the most serious gaps in the current U.S. energy innovation system—especially for large-scale technologies where public risk and cost-sharing at the demonstration stage is unavoidable.

The gap has grown wider because of the current political gridlock on Capitol Hill, which has affected many energy and climate policy initiatives, including proposals to create special federal funds and institutions for energy demonstrations. But in this case the political polarization in Washington may have opened up a new and unrecognized opportunity to solve many of the problems associated with the "demonstration gap." The approach outlined here would entail the creation of a new, regionally-based funding mechanism to reduce costs and risks and increase the volume of private financing for energy technology demonstrations. It would specifically target projects designed to demonstrate the performance of potentially transformative energy technologies at commercial scale, including nuclear, renewable, carbon capture, and grid upgrading technologies. The public funds would be drawn primarily from state-level electric power system public benefit charges or from state and regional carbon mitigation programs. The state funds would be augmented by supplementary federal grants to incentivize the creation of regional funding pools and partnerships. The regionally aggregated funds would be managed by new Regional Innovation Demonstration Funds (RIDFs), staffed by experienced professional technology and project investors.

We envision a mechanism that would ramp up over time as individual regions opted in, and that could eventually channel more than $10 billion of public and private funds annually into demonstration projects. Our approach would create new opportunities for regional differences in energy innovation needs and preferences to be expressed at the demonstration project selection stage, and it would give states a direct stake in innovation outcomes. Even in a period of flat federal budget expectations and continuing political divisions over climate change, it would generate a steady, predictable stream of funding for what has been a chronically underfinanced stage of the energy innovation system.

A checkered history

The federal government's role in energy technology demonstrations has a long history. An early example was the Atomic Energy Commission's promotion of light water reactor and other nuclear power reactor demonstration projects in the 1950s and 1960s. Less successful were subsequent efforts to demonstrate liquid metal fast breeder reactor technology and a range of synthetic fuels technologies in the 1970s and 1980s. A prominent recent example is the on-again, off-again FutureGen project to demonstrate carbon capture and sequestration. (The FutureGen project was cancelled in 2008 but was subsequently reinstated with the help of funds from the American Recovery and Reinvestment Act.) Federal loan guarantees have also been applied to energy demonstration projects over the past decade.

Taking the measure of this history is not easy. The troubled projects and programs have cast long shadows over the decades. But an unsuccessful demonstration is not itself an indicator of failure. One of the main purposes of these projects is to reveal unanticipated obstacles in bringing technologies to commercial scale. The expectation that they should always succeed is misplaced. The bankruptcy of the solar module manufacturer Solyndra in 2011 became a lightning rod for criticism of the federal loan guarantee program, which backed the company and sought to support the demonstration phase of its technology. But the fact of Solyndra's failure is not a sufficient basis for judging the program's overall effectiveness. In the last few years, the program has made 33 loan guarantees for approximately $22 billion, covering a wide range of technologies. During this period just three borrowers have defaulted, affecting about 4% of the total loan guarantee value. Indeed, it is quite possible that the program has been too risk-averse to adequately support technology demonstrations, rather than too cavalier in its selections.

On the other hand, assessments of prior Department of Energy (DOE) energy demonstration projects have identified a series of chronic problems, including:

- a systematic tendency on the part of agency officials to underestimate project costs (perhaps as a requirement to generate political support);

- a failure to plan for the possibility of future variability in fuel prices (e.g., oil price declines in the case of the synfuels program, and uranium price declines in the case of the Clinch River Breeder Reactor);
- political interference in technology selection and facility siting decisions and personnel appointments, and Congressional pressures limiting the ability of officials to adjust or terminate projects after conditions have changed;
- political cycles in Congress and the Executive Branch and the resulting lack of constancy in policy and funding over the life of the projects;
- funding and management uncertainties generated by the annual budgeting and appropriations process;
- inefficient business practices mandated by restrictive federal procurement regulations and bureaucratic rules governing human resource management, auditing requirements, and the use of federal facilities;
- the lack of a clear institutional mission at the DOE and a culture that has focused more on scientific achievement than the commercial and industrial viability of new technologies.

According to one group of knowledgeable observers, "the underlying fundamental difficulty is that the DOE, and other government agencies, are not equipped with personnel or authorities that permit the agency to pursue first-of-a-kind projects in a manner that convincingly demonstrates the economic prospects of a new technology."

Other federal agencies have done better. The Department of Defense (DOD), and within it, the Defense Advanced Research Projects Agency (DARPA), have had considerable success in demonstrating advanced military technologies that have subsequently been deployed in the field. An important reason for their success is that these demonstration projects have had identifiable clients within DOD itself—high-ranking career officers in the armed services with well-defined military missions and strong motivations to get new weapons systems into the field. The DOD demonstration teams have in turn been strongly motivated to satisfy these clients. The DOE-led demonstration projects have frequently struggled with the need to satisfy political appointees and elected officials; alignment with the actual customers, typically in industry and motivated by market and business considerations, has been weaker.

Post–demonstration energy subsidy programs have also been problematic. Rather than stimulating innovators to bring down the cost of new technologies as quickly as possible, they have sometimes had the opposite effect. Open-ended government subsidies have rewarded firms not for innovating but simply for producing regardless of cost, and the government has often been unable to ratchet down the subsidies in order to drive cost reductions, much less shut down projects and programs in a timely fashion when they have clearly failed to produce the expected results. Probably the most notorious example is the federal tax credit for corn ethanol, finally repealed in 2012 more than three decades after it was first introduced.

Good ideas going nowhere

Several proposals have been advanced to address these problems, though none is being actively pursued today. One would create a new federal financing entity, the Clean Energy Deployment Administration (CEDA), that would give high-risk energy demonstration projects and deployment programs access to various forms of financing, including loans and loan guarantees. CEDA would be a semi-independent unit within DOE.

Another proposal would go further, creating a "Green Bank" as an independent, tax-exempt corporation that would be wholly owned by the federal government. The Green Bank would support diverse technologies and projects through debt financing and credit enhancement, giving priority to those projects that would contribute most effectively to reducing greenhouse gas emissions and oil imports.

A third proposal would establish an autonomous, quasi-public corporation specifically to finance and execute large-scale energy demonstration projects. The corporation would have flexible hiring authority and follow commercial practices in its contracting, and would be governed by an independent board of directors nominated by the president and confirmed by the Senate. Along similar lines, the American Energy Innovation Council, a group of leading business executives, has proposed a public-private partnership to address these problems. Asserting that America's energy innovation system "lacks a mechanism to turn large-scale ideas or prototypes into commercial-scale facilities," the council recommended the formation of an independent, federally-chartered corporation, outside the federal government, that would be tasked with demonstrating new, large-scale energy technologies at commercial scale.

Though the details vary, all of these proposals have been designed to overcome the limitations of DOE management and to insulate projects from the political process to some degree. The new entities would be free of many of the most burden-

A critical task is to devise an innovation system in which multiple pathways can be pursued and failure is tolerable.

some federal rules. They would also have more flexibility in management and would be independent of the annual congressional budget cycle.

However, none of these proposals has advanced much in recent years. The political stalemate in Washington is an obvious and probably sufficient explanation, but even in its absence the fact that each scheme would require a one-time Congressional appropriation of $10 billion or more to be launched would have been a difficult hurdle to overcome, especially during a period of severe fiscal constraints.

What the states are demonstrating

So the federal demonstration gap remains. Could it be filled by the states? Of course, state (and local) governments have long been active in areas of policy important to energy innovation, including economic regulation of utilities, building codes and standards, and environmental and zoning regulations. California and New York have several decades of experience with large-scale energy deployment programs. Many other states have gotten into the act more recently. Thirty states have adopted renewable portfolio standards, designed to ensure a specified market share from designated energy sources such as solar and wind energy. Many state and local jurisdictions have also introduced tax measures, loan programs, rebates, or other supports for investments in low-carbon energy supplies and energy efficiency. Concerns over climate change have usually been an important motivation for these policies. So too has the goal of new job creation.

We propose to expand the footprint of these state efforts through the creation of a network of Regional Innovation Demonstration Funds (RIDFs). These RIDFs, staffed by experienced technology and project investors, would fund first-of-a-kind large-scale demonstration projects and "next few" post-demonstration projects. The RIDFs would be partly funded by revenues from state public benefit charges. (These charges, also known as system benefit charges, were first applied to consumer electricity bills in many states during electric utility restructuring as a means of ensuring continued funding for energy efficiency and renewable energy deployment as well as low income assistance and weatherization programs.) Another potential source of funding would be state or regional carbon emission reduction programs like the Northeast's Regional Greenhouse Gas Initiative (RGGI) or the California cap-and-trade program. The governors of the states participating in an RIDF would appoint the members of the fund's governing board, with representation on the board determined by state contributions to the RIDF funding pool.

Today public benefit charges applied to retail electricity sales are already generating up to $4 billion annually, some of which might be shifted to the RIDFs. Adding a dedicated surcharge of, say, 1% on all U.S. retail electricity sales would generate almost $4 billion more in annual revenues for the RIDFs. Initially only a few states might be willing to redirect existing public benefit charges to RIDF innovation financing or to implement new surcharges for this purpose. As discussed in more detail below, federal matching grants would provide incentives for additional state funding and for the creation of new regional partnerships.

Proposers would seek RIDF funding not as the primary source of finance for their projects but rather as a means of lowering the costs and risks of their own investments. Project teams could include technology vendors, power generators, transmission and distribution utilities, and third-party energy service providers, and might also include national laboratories and universities. The RIDFs would evaluate project proposals partly against standard commercial and financial criteria, including the strength of the project team, the quality of project management, and the extent of self-funding by the proposers. Most important would be the potential of the proposed project to contribute to the reduction of carbon emissions. The most attractive projects would be those with the greatest potential to stimulate major future reductions in carbon emissions while also delivering affordable, secure, and reliable energy services.

Examples of such projects could include demonstrations of integrated carbon capture, transportation and storage systems at full-scale coal and gas-fired power plants and in different geologies; small modular light water or advanced nuclear reactors; grid-scale electricity storage integrated with utility-scale solar or wind systems; and next-generation offshore wind projects. Other eligible projects might include demonstrations of advanced grid infrastructure technologies; community-scale demonstrations of grid-integrated distributed electrical storage using electric vehicles; and test beds for next-generation distribution systems with advanced demand-management technologies, micro-grids, distributed generation, and dynamic and differentiated pricing schemes.

To be eligible to receive RIDF funding, a project would first have to be certified as contributing to the public interest, based on the potential of the technology to achieve significant reductions in carbon emissions. A federal "gatekeeper" organization, the Energy Innovation Board, would be created for

How a regional structure for energy technology demonstrations would work

Additional details on how the proposed new scheme for selecting, funding, and conducting energy technology demonstrations would work are summarized here:

Regional Innovation Demonstration Funds (RIDFs): Before a project team could seek RIDF funding, the Energy Innovation Board would first have to certify that there was a public interest in the success of the new technology, on the basis of its potential to achieve significant reductions in carbon emissions at a cost competitive with high-carbon incumbent energy systems. The RIDFs would select projects based on the quality of the project team, the strength of its management, and the potential of its technology to lead to major future reductions in carbon emissions while also delivering affordable, secure, and reliable energy services. Projects selected by the RIDFs would receive direct multi-year grants, with out-year funding tied to performance. Alternatively, RIDF funds could be used for customer rebates, subsidized loan programs, credit support for PPAs, or other arrangements designed to promote user engagement with the new technology. As a condition of making a grant, the RIDF would acquire a modest equity position in the project whose ultimate value would depend on the outcome of the project and the subsequent market potential of the project technology. Each RIDF would build a portfolio of project investments distributed across states both inside and outside the RIDF's own region. Over time some specialization of the RIDFs could be expected to occur in areas of technology of particular interest to their regions—for example, offshore wind in the Northeast, or nuclear in the Southeast, or utility-scale solar PV in the Southwest, or carbon capture in the Midwest.

Energy Innovation Board: The members of the Board would include leading national experts in energy and environmental science and engineering, manufacturing, markets, and business management. The Board would also be able to hire consultants with special expertise to assist on specific matters. The Board's role would not be to determine whether a specific project proposal should be funded, nor would it rank innovations or evaluate the organizational capabilities of the proposing teams. Those tasks and decisions would be undertaken by the RIDFs themselves. The Board's role would rather be to pre-certify, decertify, or recertify projects based on its assessment of their potential to contribute to the public goal of creating cost-competitive, scalable technology options for reducing greenhouse gas emissions. Thus the Board would need to be able to evaluate the potential of scale economies and future learning opportunities. It would need to track other projects and programs targeting similar innovations to guard against duplication and overlap (although it would take into consideration the value of pursuing multiple technical approaches in parallel as circumstances warrant.) And it would need to have a global perspective and be knowledgeable about developments overseas, so that RIDF investments would not simply duplicate work being done elsewhere. Certification would only be granted for a limited period—five years, say—and could be withdrawn if progress proved too slow.

To encourage effective RIDF investing, the Board would also conduct annual reviews of RIDF portfolios, ranking most highly those combining strong representation of high-potential projects with prompt winnowing of failing projects. The highest-ranked RIDFs would be eligible to receive additional Federal matching funds.

State Trustees: Demonstration funds collected by states would be allocated to the RIDFs by state trustees. To maintain the independence of RIDF investment decisions the state funds would be allocated at the portfolio level, rather than having the trustees fund individual projects. The trustees could be elected or appointed, and would include representatives of business, environmental, and labor groups, as well as technical experts and government officials. The allocation of funds by the trustees would be based on assessments of which of the RIDF project portfolios most closely matched the interests and needs of that state's residents. In this decentralized scheme, the RIDFs would compete with one another to secure support for their portfolios from state trustee organizations. An RIDF with a portfolio deemed promising by multiple trustees would see its investment budget swell, while those with less promising portfolios would shrink.

Federal matching funds: Federal funds would be provided to the RIDFs according to a pre-determined formula that would match the allocations made by the state trustees. State funds that were independently invested in energy projects would not be eligible for the federal match. Thus the federal funds would incentivize the creation of new RIDFs and as well as additional funding of the RIDFs by the states. Federal funds would also be used to encourage effective RIDF investing by rewarding RIDFs whose project portfolios were ranked highly by the Energy Innovation Board. Disbursement of the federal funds could be administered by the Department of Energy, in lieu of its own demonstration projects, or alternatively by a separate, dedicated agency. In the latter case, there would be no reason why the Department of Energy, and its national laboratories, could not join with private partners in demonstration project teams bidding for RIDF funds.

this purpose. The Board would be an independent federal agency. Its role would be to make sure that RIDF investments were supporting the national purpose of reducing carbon emissions. All certified project proposals would have to have the potential to lead to significant reductions in carbon emissions at a declining unit cost over time. The Energy Innovation Board would not determine whether a specific proposal should receive funding, nor would it rank technologies or evaluate the organizational capabilities of the project teams. These tasks would be undertaken by the RIDFs themselves.

Let the regions decide

RIDFs would most likely be established first in parts of the country where there is already a strong commitment to innovation and interstate collaboration, and where there is existing state-level funding. Federal matching grants to the RIDFs, distributed by DOE or by a separate, dedicated agency, would create additional incentives for states to collaborate in funding these regional partnerships.

Over time, a national network of RIDFs might emerge. Certified projects could be proposed to one or more RIDFs for funding. The RIDFs could operate independently, or could co-invest with each other. With time, some specialization of the RIDFs in areas of technology of particular interest to their regions might occur—for example, offshore wind in the Northeast, or nuclear in the Southeast, or carbon capture in the Midwest.

Initially, all of the funds collected in each state would most likely be directed to the RIDF operating in its region, and even in the longer run this might be the typical pattern. But as more RIDFs were established around the country, states could, in principle, allocate funds to other RIDFs. Fund allocation would be the responsibility of a trustee organization in each state.

Implementation: Today about 30 states have implemented power system public benefit charges. The charges range from less than five-thousandths of a cent per kilowatt hour in North Carolina to nearly half a cent per kilowatt hour in California. (For reference, the average retail price of electricity in the United States is roughly 11 cents per kilowatt hour.) Altogether these charges produce revenues of $3.5 billion to $4 billion per year, and the average increase in electricity costs in the affected states is 2.1%. Over time, encouraged by federal matching funds, additional state revenues would likely be raised and more states would participate in the RIDFs. State revenues from existing public benefit charges that were redirected to the RIDFs would not be eligible for the federal match. Some states might elect to apply funds from other sources, such as state or regional carbon cap-and-trade or taxation schemes. (If adopted, the Environmental Protection Agency's proposed 111(d) rules for limiting carbon emissions from existing power plants are expected to encourage the introduction of more such schemes.)

A dedicated 0.2 cents per kilowatt hour electricity surcharge (adding about 2% to the average U.S. retail price) applied to, say, half of all U.S. retail electricity sales would generate roughly $3.7 billion per year, and might leverage up to twice that amount in private investment funds. A steady, predictable funding stream of more than $10 billion per year in public and private funding dedicated to financing demonstration and "next few" post-demonstration projects—enough to launch several new such projects each year—would be large enough to have a major impact on the nation's energy innovation challenge and is far larger than currently available funds. (DOE's entire energy-related budget for research, development, demonstration, and deployment is roughly $5 billion per year.) The magnitude of the needed federal funding is uncertain, but if, say, 50 cents of federal matching funds were required to induce each new dollar of state funding, the federal funding requirement might start at about $200 million per year and would eventually grow to about $1.8 billion per year for a RIDF network covering half the country and deploying a total of $13 billion per year in public and private funds. The net impact on the federal budget would be smaller, and might even yield net savings, as DOE would no longer need to allocate funds to costly demonstration projects.

Competition, not politics

The regionally-based public financing scheme proposed here would have several attractive features. It would create a large, dedicated funding stream for a critical part of the U.S. energy innovation system—full-scale demonstration and early adoption projects—that has been chronically under-resourced until now. RIDF funding decisions would be less susceptible to political influence than federal agency budgets, and would avoid the stop-and-go pattern that is a common feature of the annual federal appropriations process. The RIDFs could be expected to provide the steady, predictable supplementary funding that private investors would need in order to make multiyear investment commitments of their own. By putting RIDF project selection decisions in the hands of experienced technology investment

professionals, public funding would be responsive to market needs and the latest technological information, while the public interest would continue to be strongly represented by the Energy Innovation Board and the state trustee organizations.

The new scheme would also introduce multiple levels of competition into the innovation process. In the past, demonstration projects have been selected through a highly centralized and sometimes arbitrary process, in which individual congressional champions (or sometimes national laboratories) have often played very influential roles. In the proposed arrangement, project teams, once certified, would compete with each other for funds from one or more RIDFs to design, construct, and operate demonstration and post-demonstration projects, or to implement early adoption programs. (This more-decentralized scheme would also allow new entrants who may lack connections to the existing federal research and development structure to get a better hearing for their ideas than at present.) The RIDFs, in turn, would compete with one another to secure support for their portfolios from the state trustees and the federal government. An RIDF with a portfolio deemed promising by multiple state trustees would see its investment budget swell, while those with less promising portfolios would shrink. Also, as noted previously, the scheme would create opportunities for regional differences in needs and preferences to be expressed at the demonstration project selection stage, and would give states a direct stake in innovation outcomes. Of course, states where climate change and decarbonizing innovation are low priorities might choose not to participate at all.

The scheme also has a number of drawbacks. Probably the most serious is that it would entail the creation of several new organizations and would take time to set up. But while there is no time to lose in the effort to reduce greenhouse gas emissions, the energy innovation challenge is not one that can be solved overnight. The task is rather to build an innovation system capable of sustaining an accelerated flow of new low-carbon technologies over a period of decades. In this case, although the ultimate goal is to establish a national network of RIDFs, such a network could emerge gradually. Several states have already launched "green banks" or clean energy financing authorities, drawing on a range of funding sources including federal and state grants, bond issues, on-bill repayment mechanisms, and state ratepayer surcharges. Today these initiatives are mostly focused on financing the deployment of proven, commercially available technologies with low technology risk, but a new focus on technology demonstrations, designed to resolve a range of technology-related risks, could be added with modest effort.

Demonstrating diversity

A recurring problem with previous energy technology demonstration projects was not so much that they failed, but that at some point the goal became to avoid failure. For the leaders of these high-profile projects and their supporters in and outside government, the costs of failure were too great, so failure had to be avoided at all costs. But some of the strategies for preventing failure themselves proved costly, including driving out other alternatives prematurely, refusing to recognize legitimate problems until long after they arose, and failing to acknowledge that key assumptions were no longer valid. And these projects also generated a constellation of opponents, whose goal became to cause their failure, and to prevent them from producing anything useful. In this environment, the most important goals of the innovation process—generating new information and learning quickly about the strengths and weaknesses of alternative approaches—were undermined.

For large-scale energy technologies, developed in government-led and government-financed projects, these kinds of problems are ever-present risks. Yet the rapid development and deployment of such technologies will be essential to the low-carbon energy transition. So a critical task is to devise an innovation system in which multiple pathways can be pursued and failure is tolerable. The goal must be to create an institutional structure that can accommodate and promote diversity, experimentation, and competition in the innovation process—even for large-scale technologies and even during the downstream stages of demonstration and early adoption. This structure, moreover, must be robust in the face of likely continuing political divisions over the appropriate response to climate change, and it must be sustainable in the face of strong pressures to reduce federal spending. We propose the formation of RIDFs, led by states, incentivized by the federal government, and monitored and supported in the public interest by a national Energy Innovation Board, as a practical step towards achieving these goals.

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