Energy Discovery-Innovation Institutes: A Step toward America's Energy Sustainability

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The need to renew America's economy, foster its energy security, and respond to global climate change compels the transformation of U.S. energy policy. Innovation and its commercialization must move to the center of national reform. Not only must a broad range of carbon pricing and regulatory responses be adopted, but major increases in federal R&D are essential along with the deployment of bold new research paradigms. To that end, the federal government should establish a national network of regionally-based **energy discovery-innovation institutes** (e-DIIs) to serve as the hubs of a distributed research network linking the nation's best scientists, engineers, and facilities. Through such a network, the nation could at once increase its current inadequate energy R&D effort and complement existing resources with a new research paradigm that would join the unique capabilities of America's research universities to those of corporate R&D and federal laboratories.

America's Challenge

Massive sustainability and security challenges plague the nation's energy production and delivery system. Transformational innovation and commercialization will be required to address these challenges. However, current innovation efforts remain inadequate to ensure the development and deployment of clean energy technologies and processes. States and localities lack the wherewithal to make the needed investments. Additionally, numerous market failures prevent private firms from investing sufficiently in clean energy. Because firms cannot capture all the benefits of their innovative activity, they under invest and focus on short-term, low-risk research and product development.

Limitations of Existing Federal Policy

Federal energy efforts, meanwhile, suffer from two key shortcomings. First, the federal government spends less than 1 percent of its R&D budget on energy—a level less than one-fifth of expenditures in the 1970s and 1980s—clearly insufficient in light of coming challenges. Beyond that, federal energy efforts are also based on an obsolete research paradigm. Most federal energy research is conducted within "siloed" labs that are too far removed from the marketplace and too focused on their existing portfolios to support "transformational" or "use-inspired" research targeted at new energy technologies and processes.

A New Federal Approach

The federal government should create a national network of several dozen e-DIIs. An interagency process should establish the network and competitively award core federal support of up to $200 million per year for each major e-DII operated by university or national laboratory consortia, along with funding for smaller e-DIIs and distributed energy networks connected to the large e-DII "hubs." Federal funding would be augmented with participation by industry, investors, universities, and state governments, for a total federal commitment growing to roughly $6 billion per year (or 25 percent of a recommended total federal energy R&D goal of $20 to $30 billion per year). The e-DIIs would:

- ***Foster partnerships to pursue cutting-edge, applications-oriented research among multiple participants and disciplines***
- ***Develop and rapidly transfer highly innovative technologies*** into the marketplace
- ***Build the knowledge base and human capital*** necessary to address the nation's energy challenges
- ***Encourage regional economic development*** by spawning clusters of nearby start-up firms, private research organizations, suppliers, and other complementary groups and businesses

America's Challenge

Today's energy challenges stem from an unsustainable energy infrastructure, largely dependent on fossil fuels characterized by unacceptable environmental impact and supply constraints, with clear implications for America's economic health, national security, and ecological sustainability. Addressing these challenges will require a wide range of pricing and regulatory interventions as well as major investments in energy infrastructure and the demonstration and deployment of clean new technologies. But success will also require substantial—and creative—investments in clean and efficient energy technology, much of which has yet to be developed. That means that innovation and its rapid commercialization must move to the center of U.S. energy policy.

Sustainability and security challenges plague the world's energy production and delivery system. The global economy currently relies on fossil fuels for nearly 85 percent of its energy. By 2030, global energy use is projected to grow by 50 percent over 2005 levels. At the same time, recent analyses of world petroleum production, known reserves, and the impact of rapidly developing economies suggest that an increasing imbalance between supply and demand will drive up global oil and gas prices, placing the nation's economy and security at risk. While the world has substantial reserves of other fossil-fuel resources, such as coal, tar sands, and oil shale, the mining, processing, and burning of these fossil fuels with current technologies is expensive and characterized by increasingly unacceptable environmental impact in light of climate change concerns and intensive land and water utilization.

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Transformative innovation will be required to address fundamental energy challenges. As warns John Holdren, the new White House science advisor, the multiplicity of challenges that arise at the intersection of energy with the economy, the environment, and national security–led by excessive dependence on petroleum and the dangerous consequences of energy's environmental impact, particularly global climate change–requires a major acceleration of energy-technology innovation. Over time, such a push can transcend the limitations of existing energy options, bring new options to fruition, and reduce the tensions among energy-policy objectives so as to enable faster progress on the most critical ones.

Immediate impact can be achieved from adopting existing technologies and practices that improve the efficiency of energy utilization, bringing fuel savings and creating new jobs. Yet, large and sustained efficiency investments will not be enough to achieve global sustainability goals. New technologies and practices are needed to mitigate the harmful impact and resource constraints of existing energy sources. Of longer term importance is the deployment of affordable, carbon-free renewable energy technologies, which will require energy storage technologies and an expanded electricity

grid. With today's renewable technologies, a substantial gap remains in achieving the scale and cost structures necessary for major impact.

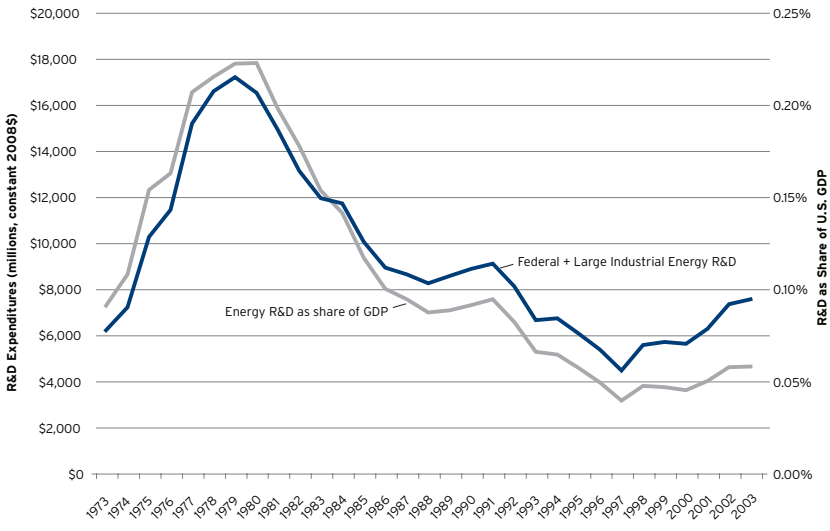
And here, increased energy R&D is needed to generate new technologies, demonstrate them on a commercial scale, and rapidly deploy them into the marketplace.

In the United States, investments in energy innovation remain inadequate to overcome multiple market and government failures that hinder problem-solving. The market and government problems are serious. To begin with, energy prices—in the absence of national price interventions and notwithstanding several oil price spikes over the past 40 years—have remained generally low enough that there has been little incentive for companies to invest in clean and efficient energy technologies and processes. Similarly, the reality of spillover benefits means that individual firms can rarely capture all of the benefits of their innovative activity, which also leads to underinvestment and a focus on short-term, low-risk research and product development. Uncertainty and insufficient information on energy pricing, policy, and the features of new technology or processes may further delay innovation. Finally, neither state nor local governments—for many of the same reasons as well as the limitations of their budgetary capacity—are likely to step in at the scale needed.

In view of this, and despite the scale and urgency of the nation's energy challenges, neither large industrial firms nor the federal government have regarded energy research as a high priority for several decades. Today's investment in energy R&D by the federal government and large industrial firms is only one-fifth the level of the early 1980s, making up just 1.1 percent of the nation's total R&D investment and 0.03 percent of the nation's GDP.

Other U.S. technology-intensive industries spend comparatively more on R&D than the energy sector. If the federal government and large industrial firms together were to invest 2 percent of the nation's annual energy sales in R&D (as the health care and agricultural sectors do), they would be investing $25 billion in energy R&D—more than six times current levels. With current spending levels, we cannot expect to see the innovative activity necessary to develop and deploy new technology, create new jobs, and boost economic growth.

The federal government's and large industrial firm's spending on energy R&D grew rapidly in the late 1970s and has since fallen off



Sources: National Science Foundation, Industrial Research and Development Survey; "Research and Development in Industry;" and "Federal R&D Spending by Budget Function."

Limitations of Existing Federal Policy

Gaps in pricing and regulatory responses, insufficient private investment, and the inability of most states and local governments to engage at the levels needed places the responsibility for investment in energy innovation largely in the federal government's lap. Such placement is also appropriate given the federal government's historic responsibilities for environmental protection and economic and national security. However, both the magnitude and character of federal energy innovation programs remain inadequate to address the scale, urgency, and complexity of the energy challenges faced by this nation.

The magnitude of U.S. energy research is inadequate. In this connection, current federal spending on energy R&D remains far too small to ensure the development of a sustainable energy economy in America. In 2007, the federal government spent $2 billion on non-defense energy-related R&D, comprising just 1.7 percent of the federal R&D budget and 0.014 percent of the nation's GDP. For 2009, estimated federal energy R&D spending is up to $2.37 billion, higher than its 1998 low of $1.27 billion but substantially lower than the $10.5 billion spent in the peak years of 1978 and 1979.

Current annual investments fall well below the $20 billion to $30 billion that some sources believe may be needed to address the climate and security threats posed by the nation's fossil fuel dependence.

The character and format of U.S. energy research remain inadequate. At the same time, today's federal energy research program lacks the mission, capacity, or the organizational structure to equip the nation to meet the full run of its challenges.

To begin with, the mission and capacity of the federal energy laboratories—which anchor the nation's present efforts—are inherently limited. The national labs do not for the most part have the mission or the capacity to build and maintain the nation's energy infrastructure, which properly remains the role of industry. Nor do the national labs play a prominent role in producing the human capital necessary to develop, build, and manage the nation's energy infrastructure, which is most properly the role of the nation's universities.

Unfortunately, neither the magnitude nor character of federal energy innovation programs is adequate to address the nation's energy challenges.

But beyond the inherent strengths and weaknesses of the lab system, today's federal energy research efforts are fragmented and insular. The Department of Energy's (DOE's) R&D offices and programs tend to be organized around fuel sources, all too often characterized by an "energy technology of the year" approach and internal competition that disrupts longer-term strategic efforts. This fragmentation leads to stovepipe organizations that focus on incremental or discrete technologies as opposed to systems that integrate R&D supply, distribution, and end-use

needs for the set of energy sources and associated infrastructures required to supply the nation with reliable, affordable, and sustainable energy. This can result in energy policies that seriously underestimate threats and consequences and are all too frequently risk-averse and parochial, tending to seriously misjudge the potential for new high-risk, high-payoff, technologically enabled opportunities and threats.

The DOE laboratories have also inherited an insular culture from the security constraints of their earlier and ongoing work in nuclear weapons development. As a consequence, the national energy laboratories have been too far removed from the marketplace and too focused on existing portfolios to support transformational research targeted at new energy technologies.

Finally, the DOE labs are also not staffed to conduct the market analysis and public policy research required for large-scale deployment of renewable energy sources, for significant gains in energy efficiency, and for reductions in fossil fuel consumption. They also lack the mission or capacity to conduct the extensive educational programs to produce the human capital and public understanding necessary to support a massive transformation of the nation's energy infrastructure.

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In sum, major innovation in research paradigms, policy, and management will be necessary to bring about the needed pace of energy-technology innovation. These improvements will be necessary to:

- Provide the scale, continuity, and coordination of effort in energy R&D and demonstration needed to bring an appropriate portfolio of improved options for the timely commercialization of breakthroughs

- Tap the nation's top scientific and engineering talent and facilities, which are currently distributed throughout the nation's research universities, corporate R&D centers, and federal laboratories

- Address adequately the unusually broad spectrum of issues involved in building a sustainable energy infrastructure, including—in addition to science and technology issues—attention to complex social, economic, legal, political, behavioral, consumer, and market issues

- Build strong partnerships among multiple players, including federal agencies; research universities; established industry; entrepreneurs and investors; regional business associations; and federal, state, and local government

- Launch robust efforts capable of producing the human capital and public understanding required by the emerging energy sector at all education levels

A New Federal Approach

A wide continuum of national, state, local, and private-sector responses will be needed to address the full scale and complexity of America's energy challenges, ranging from carbon pricing and regulation to promote clean-energy to the scaling up of smart-energy infrastructure. But for all that, the federal government should place the search for breakthrough technologies and practices at the center of its energy efforts and move to exploit in a comprehensive and interactive way the entire national research enterprise: research universities, corporate R&D laboratories, and federal laboratories.

The nation should first commit itself to increasing federal investments in energy R&D to a level appropriate to address the dangerous and complex economic, security, and environmental challenges presented by the nation's currently unsustainable energy infrastructure. Comparisons with federal R&D investments addressing other national priorities such as public health, national defense, and space exploration suggest **an investment in federal energy R&D an order of magnitude greater than current levels, growing to perhaps $20 to $30 billion per year,** with most of this flowing to existing research players and programs (e.g., national laboratories and industry).

But that responds only to the scale portion of America's research challenge. Equally important, the nation must also experiment with new energy research paradigms, and so a significant fraction of the projected investment increase should be directed toward **a new research paradigm consisting of a national network of regionally-based energy discovery-innovation institutes (e-DIIs) that serve as hubs in a distributed research network linked through "spoke" relationships to other concentrations of the nation's best scientists, engineers, and facilities.** The DII concept, developed by the National Academy of Engineering, is characterized by institutional partnerships, interdisciplinary research, technology commercialization, education, and outreach. Such institutes are designed to link fundamental scientific discoveries with technological innovation through translational research and development to create the products, processes, and services needed by society, working closely with industry and the investment community to demonstrate commercial viability and assist in market deployment. The e-DII concept would also be supportive of and complementary to similar proposals for innovative energy technology programs such as the Advanced Research Projects Agency for Energy (ARPA-E), DOE's Frontier Energy Research Centers, a National Energy Research Initiative, and a National Energy Institute. In this sense, the e-DII paradigm would place a very high priority on connection and collaboration, rather than competition, to achieve deeper engagement of the nation's scientific, technology, business, and policy resources in an effort to achieve a sustainable energy infrastructure for America.

The DII paradigm represents a contemporary adaptation of the research paradigm created through the sequence of land-grant acts passed by the U.S. Congress in the 19th century. Then, revenue from the sale of federal lands was used to create a network of university-based agricultural and engineer-

ing experiment stations on university campuses, augmented with extension services capable of interacting directly with the commercial marketplace. The program was instrumental in developing and deploying the agricultural and industrial technologies necessary to build a modern industrial nation for the 20th century while stimulating local economic growth. Today, the nation needs a similarly bold campaign to enlist America's universities and national laboratories in solving one of the most complex problems the nation has ever encountered. As envisioned here, therefore, the proposed e-DIIs would do the following:

- **Organize around a theme,** such as renewable energy technologies, advanced petroleum extraction, carbon sequestration, biofuels, transportation energy, carbon-free electrical power generation and distribution, or energy efficiency. Each e-DII would be charged with addressing the economic, policy, business, and social challenges required to successfully diffuse innovative energy technologies of their theme area into society. This mission would require each e-DII to take a systems-approach to technology development and help to transcend the current "siloed" approach common at DOE and its national labs.

- **Foster partnerships to pursue cutting-edge, applications-oriented research among multiple participants,** including government agencies (federal, state, and local), research universities, industry, entrepreneurs, and investors. The e-DIIs would encourage a new research culture based on the nonlinear flow of knowledge and activity among scientific discovery, technological innovation, entrepreneurial business development, and economic, legal, social, and political imperatives. In a sense, e-DIIs would create an "R&D commons," where strong, symbiotic partnerships could be created and sustained among partners with different missions and cultures. Building a sustainable energy infrastructure depends as much on socioeconomic, political, and policy issues as upon science and technology. The e-DIIs would encompass disciplines such as the social and behavioral sciences, business administration, law, and environmental and public policy, in addition to science and engineering.

- **Act as the hubs needed to link and support basic energy-research "spokes," distributed networks of campus-based, industry-based, and lab-based scientists and engineers,** laboratories, and research centers, consistent with the goal of coupling fundamental scientific research and discovery with translational research, technology development, and commercial deployment. But the "hub-and-spoke" network architecture would go further by enabling the basic research group spokes to interact and collaborate among themselves (through exchanges of participants, regularly scheduled meetings, and cyberinfrastructure). In this way, the direct interaction of the basic research groups would facilitate and greatly intensify collaboration and research progress, creating a basic energy research community greater than the sum of its parts and possessed of sufficient flexibility, synergy, and robustness to enable the participation of leading scientists and engineers to address the unusual complexity of the nation's energy challenges.

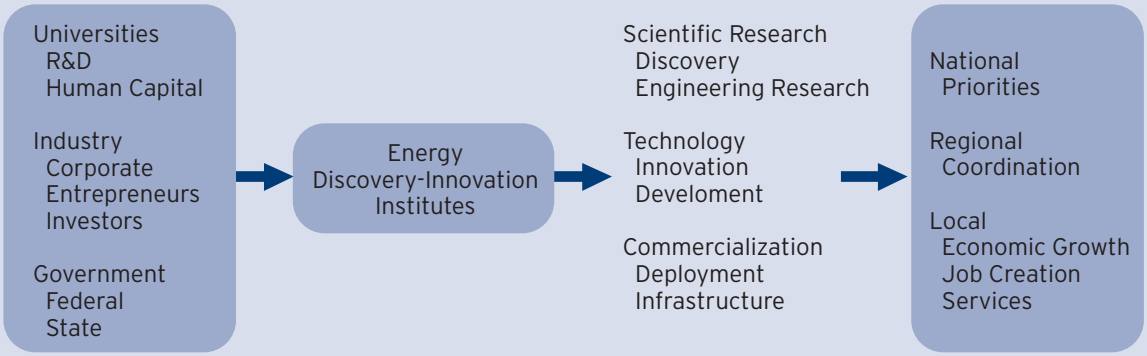
- **Execute an effective strategy for energy technology development, commercialization, and deployment,** working closely with industry, entrepreneurs, and the investment community. For example, this might draw on the experience of major medical centers (the commercialization of translational research through business startups), agricultural and industrial extension programs, federal initiatives such as the Small Business Innovation Research effort, or entirely new paradigms for technology transfer.

- **Develop and rapidly transfer highly innovative technologies into the marketplace.** To facilitate large-scale commercialization, meanwhile, the rapid transfer of new and disruptive technologies into the private sector must become a central activity of the eDIIs. Such transfer—at wholesale volumes—is crucial if massive transformation of the nation's energy infrastructure is to be rapidly achieved. So it is equally essential that publicly-funded energy research become easily and quickly available to industry, which will in most cases be the crucial disseminator of new technologies and processes. To that end, the new innovation centers should become major forums for the development of swift, efficient, and predictable technology transfer practices and successful industry-university-lab partnerships, such as those developed by the Energy Biosciences Institute, a collaboration of the University of California, the University of Illinois, the Lawrence Berkeley National Laboratory, and energy giant BP. In all cases, technology transfer should be structured to maximize the volume, speed, and positive societal impact of commercialization—and the innovation centers held accountable for performance.

- **Encourage regional economic development.** With the participation of many scientific disciplines and professions as well as various economic sectors, e-DIIs are similar in character and scale to academic medical centers and agricultural experiment stations that combine research, education, and professional practice and drive transformative change. This organizational form has been successful at generating jobs and stimulating regional economic activity, by the nearby location of clusters of start-up firms, private research organizations, suppliers, and other complementary groups and businesses. The e-DIIs should have an explicit mission to focus, at least in part, on the unique energy needs and opportunities characterizing their home regions, to ensure that new technologies would respond to local challenges and thus could be rapidly deployed.

- **Build the knowledge base, human capital, and public awareness necessary to address the nation's energy challenges.** The e-DIIs are also envisioned as the foci for long-term, applications-driven research aimed at building the knowledge base necessary to address the nation's highest priorities. Working together with industry and government, the e-DIIs would also lead the development of educational programs and distributed educational networks that could produce new knowledge for innovation and educate not only the scientists, engineers, innovators, and entrepreneurs of the future, but learners of all ages, about the challenge and excitement of changing the U.S. energy paradigm. In this fashion the e-DIIs would take on a fundamental educational mission through the involvement of their scientists and engineers in sharing educational best

Energy discovery-innovation institutes would draw from a diverse support network, conduct widespread activities, and be oriented towards achieving important social goals



practices and developing new educational programs in collaboration with K–12 schools, community colleges, regional universities, and workplace training organizations.

- **Expand the scope of possible energy activities.** The partnership character of the e-DIIs, involving a consortium of universities, national laboratories, industry, investors, states, and the federal government, coupled with its regional focus, would give it the capacity to launch projects that are beyond the capability of a national laboratory or industry consortium alone.

An interagency process should establish the network and competitively award core federal support ranging up to $200 million a year for each major e-DII operated by university consortia or a national laboratory, along with funding for smaller energy research centers connected by "spokes" to the large e-DII "hubs." Federal funding would be augmented with strong additional support and participation from industry, investors, universities, and state governments, for a total federal commitment growing to roughly $6 billion per year (or 25 percent of the recommended total federal energy R&D goal of $20 to $30 billion per year estimated to be necessary to adequately address the nation's energy challenge.)

Three sorts of institute would anchor the national network:

- ***University-based e-DIIs:*** Those e-DIIs located adjacent to research university campuses would be managed by either individual universities or university consortia, with strong involvement of partnering institutions such as industry, entrepreneurs and investors, state and local government, and participating federal agencies. While most university-based e-DIIs would focus both on research addressing national energy priorities and regional economic development from new energy-based industries, there would also be the possibility of distributed or virtual e-DIIs (so-called "collaboratives") that would link together institutions on a regional or national basis. As mentioned earlier, each e-DII would also act as a hub linking together investigators engaged in basic or applied energy research in other organizations

- ***Federal laboratory-based e-DIIs:*** There should be a parallel network of e-DIIs associated with federal laboratories. To enable the paradigm shifts represented by the discovery-innovation institute concept, these e-DIIs would be set up "outside the fence" to minimize laboratory constraints of security, administration, and overhead and would be driven by the bottom-up interests of laboratory scientists. Like university-based e-DIIs, their objectives would be the conduct of application-driven translational research necessary to couple the extraordinary resources represented by the scientific capability of the national laboratories with the technology innovation, development, and entrepreneurial efforts necessary for the commercial deployment of innovative energy technologies in the commercial marketplace. A given national laboratory might create several e-DIIs of varying size and focus that reflect both their capabilities and opportunities. There might also be the possibility of e-DIIs jointly created and managed by national laboratories and research universities

- ***Satellite energy research centers:*** The large e-DIIs managed by research university consortia or national laboratories would anchor "hub-and-spoke" sub-networks linking smaller energy research centers comparable in scale to DOE's Energy Frontier Research Centers or the National Science Foundation (NSF)'s Engineering Research Centers, thereby enabling faculty in less centrally-located regions or at institutions with limited capacity to manage the large e-DII hubs to contribute to the nation's energy R&D as an element of the e-DII network

In terms of its establishment and build-out, the new network would be developed through a competitive award process with gradual phase-in:

- ***Award process:*** A competitive award process should be adopted to designate e-DIIs for federal support and inclusion in the network. Proposals should be evaluated by an interagency panel and subjected to comprehensive peer review. A framework of energy research strategies and priorities should be developed to guide the decision process, perhaps with the assistance of independent advisors such as the National Academies or a new structure such as the proposed National Energy Institute or the advisory board of a possible new Energy Research Initiatives program. Because of its long experience in conducting merit-based competitions for large research centers (such as the Engineering Research Centers and Science and Technology Centers), the NSF should be considered the lead federal agency in managing the e-DII award process. Successful proposals would then receive core funding by individual federal agencies or through interagency agreements to support and anchor the main programs of the e-DII and to provide for infrastructure. To achieve a balanced utilization of all elements of the nation's research triad of federal laboratories, corporate R&D centers, and research universities, the e-DII competitive award process for university-based e-DIIs and federal-laboratory-based e-DIIs should be kept separate and within specified total funding envelopes. For example, consideration of both the relative number of world-class research universities and national laboratories, as well as the fact that the national laboratories would also benefit from very substantial growth of the total federal energy R&D investment (e.g., to $20 to $30 billion per year) suggests that an appropriate target might be $4 billion per year for the university e-DIIs program and $2 billion per year for the federal-laboratory version

- ***Award criteria:*** Although the primary award criteria for e-DII awards should be scientific merit and capability, other criteria should be considered such as commitments by participating partners (e.g., industry, investors, and state or local governments), the strength of the management plan, strategies for commercialization (e.g., approaches to technology transfer and intellectual property issues), integration of the e-DII into the regional economy, and plans for the associated hub-and-spoke network capable of linking both to the national energy research network (NREN) and campus- or industry-based scientists. A demonstrated ability to reduce carbon emissions or achieve other quantifiable goals would also matter. Furthermore, consideration would be given to the ability of the proposed e-DII in leveraging investments from other actors in the energy research enterprise, ensuring a larger overall commitment to addressing the nation's energy challenges

- ***Phase in:*** The e-DII network should be phased in over time, so it can benefit from ongoing evaluation and assessment. Each e-DII should be subject to rigorous evaluation at regular intervals, together with ongoing assessment of the effectiveness of the network in terms of research results, funding matches, commercial spinoffs, and human resource production. In this fashion, five e-DIIs a year could be launched over a five- to 10-year period to create the full network, with the early e-DIIs being viewed as prototypes to refine policy and operational issues (e.g., management, intellectual property, and coordination). While long-term energy research would require sustained funding of the network, it would also be possible to place a sunset of 12 to 15 years on each e-DII so that re-competition for federal support would occur

As to their operation, the institutes would benefit from a tiered organizational structure and strong network characteristics:

- ***Tiered organization:*** The e-DIIs would utilize a tiered organization and management structure. Since the proposed network represents a departure from existing research paradigms, it requires an independent institutional and management structure committed to overseeing basic research through rapid deployment of new technologies. Each e-DII should have a strong external advisory board representing the participating partners, including government (federal and state), industry, interested nonprofits, entrepreneurs, and investors. In some cases, partners might play direct management roles with executive authority. The precise organizational and management structure for e-DIIs is not prescribed here, as it should be a component of the evaluation process to award the e-DII funding. This way the proposal process encourages competition, creativity, and innovation and ensures that the e-DIIs have maximum flexibility to achieve meaningful advances in energy research and technology development

- ***Linked external relationships:*** The e-DII network should function in a coordinated, integrated manner. To this end, the e-DII network should be undergirded by powerful information and communications technology (i.e., cyberinfrastructure) and overlaid by a network of virtual organizations involving scientists, engineers, industrial management, and federal participants. This way the

network would provide a powerful test-bed for the new types of research organizations enabled by rapidly evolving cyberinfrastructure, such as collaboratories and immersive virtual environments, which reduce unnecessary duplication of costly research facilities and cumbersome management bureaucracy. Such coordination would allow separate e-DIIs, focused on different themes, to remain connected and coordinated in pursuit of larger national goals

In terms of administrative and budgetary design, multiple options exist for administering the e-DII network and funding it.

- ***Administration.*** Any new federal energy research effort would ideally be established, managed, and funded as an interagency effort rather than as the responsibility of a single department. This would follow the precedent of such other ambitious, multidimensional initiatives as those the nation is mounting in nanotechnology, high performance computing, and global climate change. Agencies that might be involved in the e-DIIs network, meanwhile, include Energy, Defense, Commerce, Transportation, Agriculture, as well as the Environmental Protection Agency, the National Science Foundation, and the National Institutes of Health. Oversight of the interagency effort could be placed within the Executive Office of the President's Office of Science and Technology Policy (OSTP) or within a lead agency. Locating this initiative entirely within DOE is an option, but one that could be problematic due to the limitations of federal energy activities raised in this report. To achieve a balance among participants (e.g., DOE labs, industry, higher education, and the states) should this scenario be adopted, a new senior position in DOE would likely need to be created, such as an Under Secretary or a Level II Presidential appointment similar to the Deputy Secretary with responsibility for the total energy program, such as "Director of the Energy 2020 Project." The initiative should also be legislatively freed of much of the contract, legal, and other procedures of DOE, and perhaps given a direct relationship with the Office of Management and Budget. It should have monies appropriated to it that are for pass-through or coordination with other agencies so that a true interagency character can be developed. An alternative arrangement would be to appropriate funds directly to other federal agencies and enable them to fund the e-DIIs directly, although this would create the additional complexity of coordinating among multiple appropriations subcommittees

Any new federal energy research effort would ideally be established, managed, and funded as an interagency effort rather than as the responsibility of a single department.

- ***Funding.*** Several options also exist for funding the core federal support of national energy research network. Funding could be diverted from existing subsidies of $14 billion per year for energy-related activities. Several of these activities are unnecessary or, at the least, have questionable effectiveness. Funding could result from a carbon tax or the auction of carbon cap-and-trade allowances. Revenues from carbon allowances are estimated to yield $100 billion per year once implemented, growing to as much as $500 billion per year over the next several decades.

Allowance revenues will be years in coming, and will have many demands for their use, while energy investments are urgently needed. Finally, the e-DII network could be funded out of general revenue and deficit-financed, if necessary, which would be appropriate given the long-term and widespread social benefits of energy investments

In all of this, meanwhile, it is important to stress that the proposed network of energy discovery-innovation institutes is designed to align with, support, and complement other innovative approaches to energy research, technology development, commercialization, and deployment. In particular, the proposed ARPA-E could play a major role in stimulating truly transformational research within both the e-DIIs and their associated networks of investigators. Similarly, the proposed DOE Energy Frontier Research Centers could also be viewed as complementary or coordinated with the e-DII networks. The e-DII network is also well-aligned with a possible New Energy Research Initiative or an eventual National Energy Institute, which could provide strategic guidance and coordination for the e-DII network. Finally, programs that would provide long-term grants to outstanding junior investigators (analogous to NSF Young Presidential Investigator Programs) or senior scientists (analogous to the Howard Hughes Medical Institute Fellows program and the KAUST research grant program) are both highly compatible with the e-DII network, which could assist in coordinating and supporting these activities.

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In the end, the need to reinvigorate America's economy and place it on a more sustainable footing compels the transformation of U.S. energy policy.

Quite simply, the sheer scale and unprecedented complexity of the nation's "energy problem" requires a new approach—one that rethinks both the magnitude and character of national energy research programs, and places innovation at the center of reform efforts.

In this vein, the construction of a national network of regionally-based energy discovery-innovation institutes represents a worthy successor to the visionary modernization of American agriculture and industry undertaken with the Hatch Act of 1887. With that legislation, a far-sighted nation expanded the mission of the nation's land-grant universities with the creation of state agricultural experiment stations that helped revolutionize American agriculture and advance industry through a multi-disciplinary partnership involving higher education, business, and federal, state and local government. Now, the time has come again for America to innovate. By creating the proposed network of e-DIIs, a resilient nation should catalyze a new partnership of research universities, federal laboratories, business and industry, entrepreneurs and investors, and federal, state, and local government to stimulate strong regional economic growth while inventing a sustainable national energy infrastructure for the 21st century.

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The full-length paper from which this brief is drawn is available at
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