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Jumpstarting a Clean Energy Revolution with a National Institutes of Energy

By Josh Freed, Avi Zevin, and Jesse Jenkins*

OVERVIEW

When the United States faces a significant challenge and decides it is critical to act—sending a man to the moon, winning the Cold War, curing deadly disease—we make a national commitment and invest the resources necessary to meet it. Time and again, as the nation has confronted and overcome these clear imperatives, a substantial and sustained boost in federally supported research and development has been a key driver of our success.

Getting America running on clean energy—the defining challenge and opportunity of our time—will require a new national commitment to energy innovation.

Currently, the federal government lacks both the structure and the financing necessary to meet the energy challenge. The scale and complexity of the challenge before us demands a coordinated and well-funded national effort to transform the global energy sector, yet US policy in this area relies on haphazard financial and political support with little consistent direction. In order to jumpstart a clean energy revolution, the US government must increase its direct support for research and development of new and existing clean energy technologies and create a new structure for energy research that ensures coordination and maximizes its effectiveness.

A successful national energy R&D program capable of driving the innovation necessary to make clean energy cheap must embrace two key components:

1. Increase federal investment in energy R&D by $15 billion per year

In line with President Obama's budget request,[1] the scale of investment for comparable national priorities, and the recommendations of innovation experts,

* This paper is the joint product of Third Way and the Breakthrough Institute. Our organizations hold differing positions on several policy questions, including notable aspects of the current debate surrounding congressional climate and energy policy proposals. Despite differing positions on other questions, our organizations strongly agree on the importance of significantly expanding American investment in clean energy research and development. That is why we have joined together to co-author this memo on how to jump start American energy research and development (R&D).

we propose a sustained $15 billion per year increase in federal clean energy R&D to approximately $20 billion per year.[2] This level of funding is necessary to both create new breakthrough technologies and drive improvements to existing technology, enabling the production of clean energy at significantly higher efficiencies and lower costs.

2. Create a National Institutes of Energy

Modeled on the National Institutes of Health, a new National Institutes of Energy (NIE) would effectively apply R&D funding to the goal of developing new, low-cost commercial clean energy technologies. The NIE would function as a nationwide network of regionally based, commercially focused, and coordinated innovation institutes. Alongside other effective federal energy R&D agencies, a new NIE would critically strengthen the U.S. clean energy innovation system.

INCREASE THE FEDERAL COMMITMENT TO ENERGY R&D BY $15 BILLION PER YEAR

Currently, the United States does not have the full portfolio of technologies it needs to transition to clean, affordable energy, and we are not moving quickly enough to develop them. There is widespread agreement among innovation experts and energy researchers that neither the private sector nor the federal government is sufficiently invested in creating the new technologies we need or improving the technologies we have today. Only the federal government is able to provide the additional $15 billion in sustained annual funding energy experts believe is necessary to develop clean, affordable energy technologies.

Energy innovation is critical to meet current and future challenges

The United States faces an economic crisis, national security threats and global warming, all due, in part, to the nation's current dependence on an aging energy infrastructure overwhelmingly reliant on conventional energy. Unfortunately, today's clean energy technologies are insufficient, in both scale and cost, to replace fossil fuels. In order to get America running on clean energy, the United States must invent new clean energy technologies while accelerating the pace of improvement for today's suite of clean energy alternatives.

The Scale of the Challenge

Currently, the United States gets 70 percent of its electricity and over 90 percent of its transportation fuel from conventional fossil energy sources.[3] Existing clean energy technologies can make an impact in reducing our use of conventional fuels but cannot generate or store enough power to come close to eliminating them.[4] Given the need to significantly reduce greenhouse gas emissions and eliminate our dependence on volatile global oil markets, we will need to develop new clean energy technologies that the United States can quickly deploy throughout the economy. As Energy Secretary Steven Chu notes, it is a "myth [that] we have all the technologies we need to solve the energy challenge... We need new technologies to transform the [energy] landscape."[5]

The Clean Energy Price Gap

Cost is a significant barrier to the deployment of clean energy, even for technologies that are available today. While deployment of wind, solar, and other renewable technology has expanded dramatically, they still contribute a very small portion of U.S. energy needs and remain significantly more expensive than traditional sources of energy.[6] The private sector, then, will not use current generation technology to replace conventional energy on its own. And price volatility and the uncertainty of government support for current generation technology has limited private investment even when subsidized prices are competitive with conventional energy, such as with wind.[7]

While additional deployment of existing technologies can help lower the clean energy price gap,[8] research and development on new and existing technologies holds the key to reducing unsubsidized prices and encouraging private sector investment in the deployment of clean energy.[9]

The Challenge to Compete Globally

Because of the size of the energy sector and the scale of transformation needed, energy is one of the few areas of the economy capable of serving as a major new engine of economic growth.[10] By 2030, overall demand for energy in the U.S. is expected to increase by more than 11.5 percent, with electricity demand expected to rise 24 percent.[11] Growth will be even more striking globally, with demand expected to grow by 50% by 2030.[12]

Given this anticipated increase in energy demand, the countries that develop new energy technology the fastest will have significant economic and competitive advantages. The United States was the leader in nuclear, solar and wind energy development in the 1970s. Government policies and economic conditions in the 1980s, however, led to a decline in American research and development and the rise of innovation and industries in other countries including Denmark, Germany, Spain, Japan and China.[13] The U.S. imported 50 percent of annually installed wind turbine components in 2007,[14] currently produces less than 10% of the world's solar cells,[15] and is continually losing ground on hybrid-electric vehicle manufacturing. Unfortunately, the lack of a sustained national commitment to clean energy innovation is already limiting our access to a major economic driver of the next century.[16]

Without immediate action to spur clean energy technologies and industries, the United States may also fall behind several Asian nations now aggressively positioning themselves to dominate the burgeoning clean energy sector. The Chinese government is reportedly developing a plan to invest $440-660 billion in clean energy over the next ten years[17] and has announced ambitious targets for wind, solar and plug-in hybrid and electric vehicle production.[18] South Korea recently announced a "Green New Deal" to invest $84 billion over the next five years to expand research and development and spur the growth of renewable energy, LEDs, smart grid, hybrid vehicle and other clean technologies—a sum representing two percent of the nation's Gross Domestic Product (GDP) each year.[19] Similarly, Japan will invest $30 billion over the next five years to support R&D in a suite of low-carbon technologies[20] while redoubling incentives for solar energy as part of a plan to become the "number one solar power in the world."[21]

Current US energy research and development is not sufficient to spur innovation

Neither the public nor private sectors in the United States invest the resources in energy innovation necessary to develop the new technologies that will be needed to meet the challenges of the 21st century.

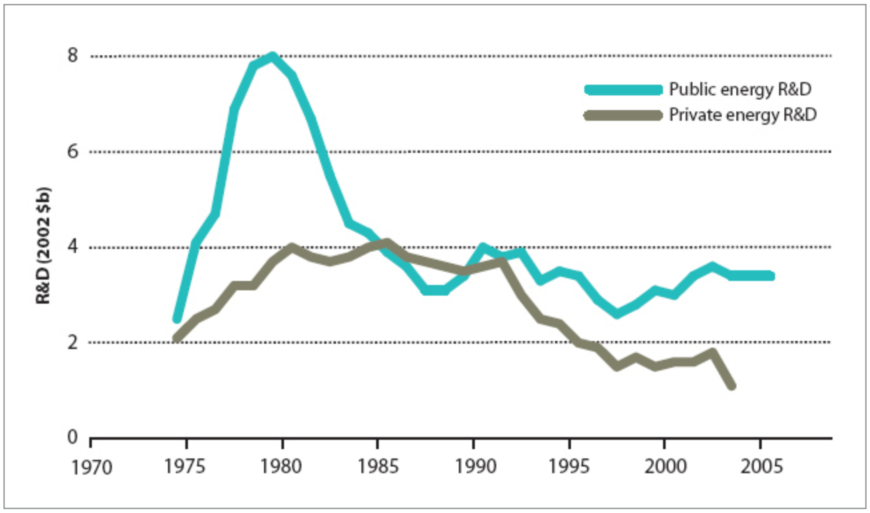

Figure 1. Historic Public and Private Investment in Energy R&D, 1970-2005[22]

The Private Sector does not invest sufficiently in energy R&D.

Large industrial firms in the U.S. spend well under $3 billion annually on energy R&D in an industry with well over a trillion dollars in annual revenue.[23] This is less than one quarter of one percent of revenues, significantly less than current innovation-intensive growth industries such as biotechnology, health care, and information technology, which routinely invest 5 percent to 15 percent of revenues in R&D activities,[24] and even dwarfed by other well established industries such as electronics (8%) or automobiles (3.3%).[25] This problem is not confined to the United States. As John Holdren, Director of the White House Office of Science and Technology Policy, noted: "Around the world, the energy sector's ratio of [research and development] investments to total revenues is well below that for any other high-tech sector in the economy."[26]

Furthermore, while venture capital funding for clean technology has increased dramatically in the past five years, the current level of VC investment, roughly $3.7 billion in 2007 and expected to decrease significantly due to the economic recession,[27] still amounts to one quarter of one percent of the roughly $1.5 trillion annual revenues in the combined U.S. energy and transportation sectors.[28] And while venture capital has been a boon to new energy technology, the current economic crisis[29] and a recent focus by VC funders on commercialization rather than research[30] leaves a critical hole in our energy development pipeline.

These problems have been getting worse, not better. Despite an expanding energy industry and growing public and political support for clean energy, private sector investment in energy R&D has fallen by more than half in recent decades.[31] Private sector investment is now so low that the R&D budgets of individual biotechnology companies exceed the combined total of private-sector investment in energy R&D.[32] New patents, a measure of energy innovation, have seen a corresponding decline.[33]

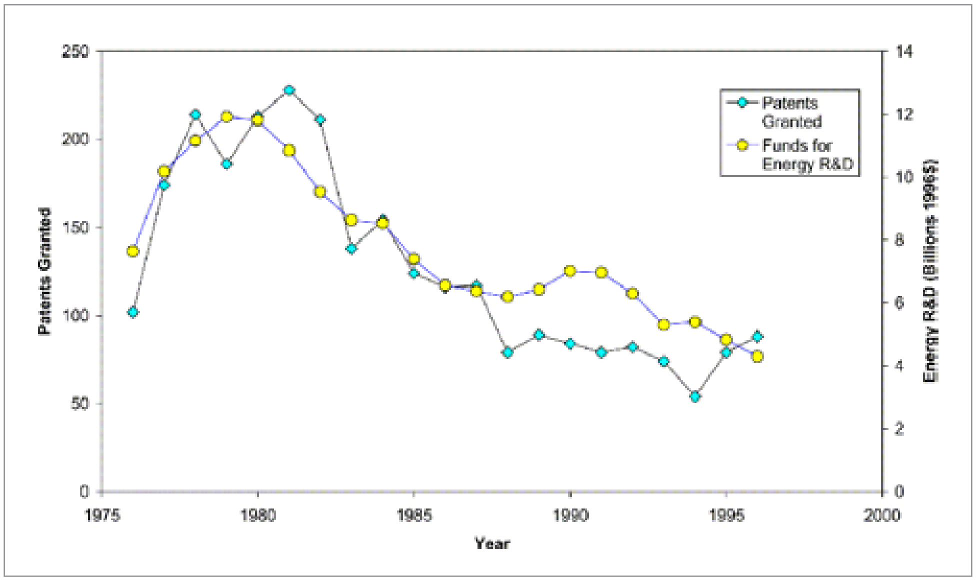

Figure 2. Decline in Energy Patents mirrors decline in R&D. 1975-2000.[34]

Government commitment to energy R&D does not fill the gap.

The federal government has failed to bridge the gap of support for clean energy research and development left by the private sector's lack of spending. In

2007, the federal government spent just $4 billion on energy-related R&D programs at the Department of Energy—less than half the R&D spending of one US pharmaceutical company—and comprising just 3 percent of total federal R&D investments and an anemic 0.03 percent of U.S. gross domestic product (GDP).[35] This is significantly less than the federal government's commitment to other past and present national priorities, and even prior government investments in the energy sector. Funding for DOE programs engaged in energy R&D has increased somewhat in recent budget cycles to roughly $5 billion in FY2009,[36] but remain inadequate to the challenge at hand.

By contrast, the federal government currently spends roughly $30 billion annually for health care research—after doubling funding in only 5 years—and Congress appropriates over $80 billion per year on defense-related R&D.[37] Perhaps most concerning, if the nation's commitment to clean energy R&D had merely remained constant since the "Project Independence" energy initiative launched after the 1970s oil crises, the United States would be spending $14 billion per year today, roughly triple today's funding levels.[38] The scale and urgency of national energy challenges have only increased since the 1970s, yet the national commitment to energy innovation has moved in the wrong direction.

Experts from around the world now agree, a "principle barrier to low carbon innovation [is]… ' a strong, well coordinated and well financed' government R&D strategy."[39]

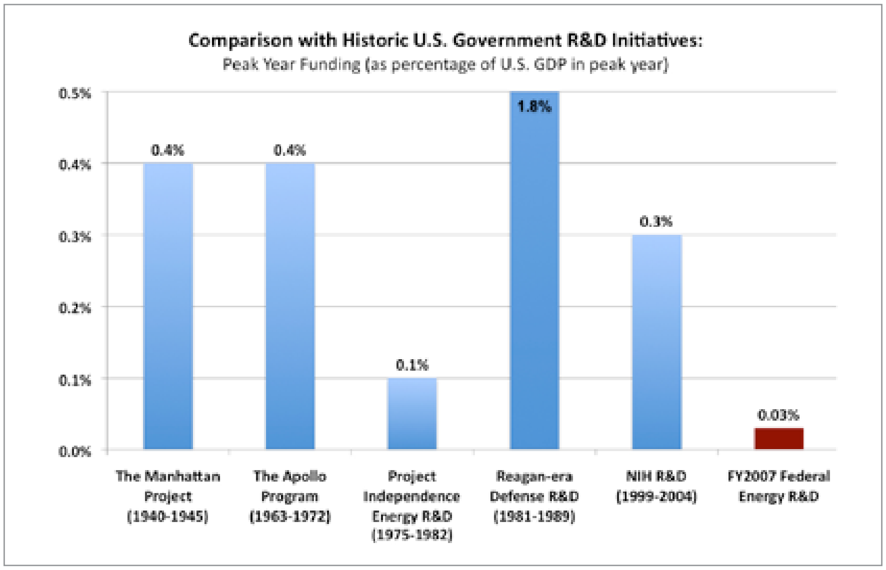

Figure 3. Comparison of Historic Federal R&D Initiatives and Current Federal Energy R&D Spending[40]

Federal spending on energy R&D should be increased by $15 billion per year

President Obama agrees that current government spending on energy R&D is insufficient, and he has called for a sustained $15 billion increase in clean energy technology research and development, bringing overall federal investments to roughly $20 billion annually.[41] This is in line with the findings of many of the leading energy research experts. John Holdren, Director of the White House Office of Science and Technology Policy, estimates we need between two and ten times as much funding for energy research as we currently have.[42] Two of the country's leading energy innovation experts, Professors Gregory Nemet and Daniel Kammen, have called for at least $17 billion annually in energy research.[43] The Brookings Institution has found that the U.S. needs to spend at least $20 billion per year.[44] The Climate Group and the Office of Tony Blair have called on the world's developed nations to at least double public R&D spending by 2015 and quadruple it by 2020.[45] And 34 Nobel laureates recently sent a letter to President Obama calling on him to ensure that any clean energy legislation Congress passes includes the $15 billion per year for clean energy R&D the President requested.[46]

We agree with this diverse group of experts. At minimum, Congress should appropriate adequate funding to provide a sustained increase in federal clean energy R&D investments consistent with the President's budget request – sufficient to roughly quadruple annual R&D investments over time. This new funding should be used to strengthen and augment the most effective federal energy research programs, support innovative new paradigms to structure federal energy R&D, and in particular, fund the establishment of a new National Institutes of Energy, outlined in section two.[47]

CREATE A NATIONAL INSTITUTES OF ENERGY

To meet the need for clean, affordable and secure energy to power the 21st century economy, we recommend creating a new institution focused on the type of energy innovation that can lead to breakthrough commercial energy technologies: a National Institutes of Energy.

Current federal institutions are not sufficiently focused on effective energy R&D

While investing dramatically more in energy R&D is critical, it is not enough to drive innovation at the pace and scale required. The federal government must also find new and effective ways to invest taxpayer money.

The Department of Energy (DOE) was not intended to prioritize the types of innovation that will lead to new commercial energy technologies that the private sector would adopt. DOE was created from a collection of nuclear weapons-related departments, such as the Manhattan Project and the Atomic Energy Commission. To this day, the majority of the Department's funding and attention remains focused on managing—and cleaning up after—the nation's sprawling nuclear weapons arsenal, rather than on the commercial uses of energy that are today's priorities.[48]

The government energy research that does exist is primarily focused on the national laboratories. While critical for basic research, the national labs are not designed to produce the advances that can lead to new commercial and deployable clean energy technologies. This is because the labs are often too far removed from the needs of the marketplace, and their focus remains split between a broad range of basic science endeavors.[49]

The other existing DOE offices lack sufficient focus, coordinated priorities, or the optimal structures needed to maximize public-private partnerships. Centralized in Washington DC and chronically underfunded, the DOE offices managing applied R&D programs are responsible for everything from actual research to deployment, home weatherization, and other only loosely related tasks. Without a primary focus on research and development, current DOE institutions are incapable of the rapid translational research necessary to bridge basic science insights and applied research challenges.

It should be noted that others have also proposed various new structures for coordinating an expanded commitment to energy R&D. These include: The Brookings Institution's Energy Discovery-Innovation Institutes proposal, DOE Energy Innovation Hubs,[50] and the American Clean Energy and Security Act's Clean Energy Innovation Centers.[51] While the NIE idea draws from many of these proposals and Congress should experiment with multiple innovative approaches to energy innovation, we believe any successful R&D institution should meet the following three key critical principles:

1. **Easy to understand and based on existing public support.** The public is broadly supportive of government sponsored R&D efforts, particularly when tied to institutions that they trust.[52] The model and name of any new agency should be easy to understand and remember, and should be used to sustain public support.
2. **Centrally coordinated but regionally based.** Some of the current R&D proposals centralize decision-making in a Washington office and therefore lack the regional and local perspectives that can draw on existing resources and speed up commercialization. At the same time, other

proposals call for entirely decentralized systems that lack critical coordinating authority. This risks waste and overlap, which could dramatically slow development of promising technologies. Any new institution should draw on the strengths of both central coordination and regional expertise.

3. **Outside of the current DOE research framework.** While DOE does contain important research and applied offices (like Basic Science, Energy Efficiency and Renewable Energy, Fossil Energy and Nuclear Energy), these divisions lack the central guiding focus and coordination that effective energy R&D requires. Given the level of resources required to meet the challenge of transforming the energy sector, these structures are insufficient, and any new institution should not be fragmented across multiple DOE offices.

America needs a National Institutes of Energy

Use NIH as a model.

A new National Institutes of Energy (NIE) should be established to create and oversee a network of regionally based, applications-oriented, coordinated energy innovation institutes, working with top talent from the nation's leading research universities, national labs, and private sector innovators. Modeled on the successful National Institutes of Health, a National Institutes of Energy will provide an additional research institution designed to most efficiently prioritize the development of commercially deployable and cost-competitive energy technologies.

NIH serves as an important model for a new energy innovation institution because of its successful organizational structure, clear mission, and broad public support. The NIH has a unique structure, with 20 decentralized institutes and seven multi-disciplinary research centers. These disparate offices are coordinated by a centralized Office of the Director, allowing the institutes and centers to take advantage of results-oriented expertise while maximizing information sharing and multi-disciplinary discoveries. This dual model should serve as the basis for the organization of the National Institutes of Energy.

Each institute and research center has its own director and its own advisory council, comprised of scientists, health advocates, and laypersons. This enables the institutes to conduct their own research and, simultaneously, evaluate and award grants to extramural R&D projects across the country. One of the reasons that NIH has been so successful is that it funds both outside research through individual grants with critical peer review from a diverse community of scientists (depoliticizing individual funding decisions), and also conducts research in-house.

The National Institutes of Energy would be created to competitively fund a network of one to two dozen individual Energy Institutes at $50 million to $300 million per institute per year, as well as several larger multidisciplinary research centers.[53] Like the NIH, institutes would be largely independent and autonomous, with multiple methods for funding path-breaking research, including in-house research programs and grants for extramural research at public, non-profit and private sector research facilities. And like the NIH, each institute would have its own director and advisory council to determine funding and research priorities and grant awards.

While decentralization is important, maximizing effectiveness requires coordination. Similar to the NIH Director,[54] the director of NIE would provide oversight and coordination, and establish overall priorities for the network of energy institutes. The director will also serve as the NIE's advocate to Congress and the Administration.

According to a 2003 National Academy of Science report, NIH would, in fact, benefit from added levels of coordination. In line with their recommendations for the NIH, NIE's Office of the Director would have added coordinating responsibilities. The Director would have a budget, 5% of total NIE appropriations, to fund "special projects" that focus on trans-NIE, high-risk and high-reward research that is often disadvantaged in the traditional process of peer-reviewed research and grants.[55] Furthermore, the Office of the Director would be responsible for working with industry to identify key gaps in current technology and research and working with individual institutes to ensure effective technology road mapping.[56]

Unlike other recent R&D proposals,[57] NIH's unique combination of decentralization and central coordination (particularly after implementing NAS recommendations) will make a National Institutes of Energy a critical and effective energy R&D institution.

Offer a clear and directed mission.

The mission of the NIH, to fund and conduct groundbreaking medical research throughout the United States, is simple and clear. The National Institutes of Energy should also have a singular mission focused on energy R&D: developing the commercial and affordable clean energy technologies of the future.

The Energy Institutes would be designed to integrate fundamental scientific discoveries with applied innovations and work closely with industry, entrepreneurs and the investment community to rapidly develop clean energy technologies and transfer them to the marketplace. The NIE, then, could have an even greater focus on translational research, and incorporate a greater percentage of high-risk, high-reward research, than the NIH (which is focused less on market-place impact).[58]

NIE would organize each institute around a primary mission, such as solar energy, carbon sequestration, advanced biofuels, electrified transportation, advanced energy technology manufacturing, or the transmission, storage and management of clean electricity. This is modeled on NIH's structure, where each institute is focused on a specific area of health such as the National Institute of Cancer.

Leverage expertise through regional institutes.

Unlike the NIH, whose many centers all conduct in-house research primarily at a single campus near Washington, individual energy institutes should be physically located in diverse regions across the country. Research performed by each institute would respond to the particular needs, challenges and capabilities of the region in which the institute is based. In the process, the energy innovation institutes established by NIE will help drive regional economic development and create jobs in new, high-tech industry clusters that will take the innovations emerging from NIE-funded institutes to market.

To take advantage of the existing networks and researchers across the country, institutes should develop close relationships with university research centers and operate in partnership with existing federal research institutions, including existing National Labs, and private research firms.[59]

Provide independent funding and organization.

A new National Institutes of Energy would be nominally housed within the Department of Energy, similar to the way NIH resides within the Department of Health and Human Services. However, just as with NIH, the new NIE would have separate congressional authorization, and a high degree of budgetary and staffing autonomy for each of the institute directors.[60] The NIE staff and advisory boards of each institutes should be free to direct funding to individual researchers, in-house R&D programs and public and private research grants, consistent with the mission of that institute and the overall priorities set by the NIE Director.

Maximize public support.

Public and political support is critical to the success of any federal agency. NIH has received broad support from policymakers and the public, and has demonstrated how such support can critically improve the ability for an agency to meet its mission. In 2005, NIH was ranked as the third most popular federal agency after the CDC and FBI, with 75% of the public rating the agency positively.[61]

The public is also broadly supportive of government's commitment to R&D. A recent Pew survey found that 60% of the public agrees that "government investment in research is essential for scientific progress." And large percentages think that government investments in basic scientific research (73%) and engineering technology (74%) pay off in the long run.[62] A detailed May 2009 analysis of American attitudes on climate and energy policy found expanded clean energy research was the most popular policy response presented to respondents, garnering near unanimous public support (92%).[63] An institution that is easily identifiable and meets these goals can help build broad support for clean energy innovation as NIH has done for healthcare.

NIH's support is not limited to the public. In a 2003 review of the agency, the National Academy of Sciences found that NIH is "one of the most effective and well-managed elements of the federal government and a centerpiece of its R&D system."[64] Most importantly, the agency's substantive and popular success has brought it attention from policymakers. This resulted in a doubling of its budget to approximately $30 billion between 1998 and 2003, allowing NIH to greatly expand its ability to meet the nation's health challenges.[65]

A new energy R&D institution, modeled on this successful agency, can put a high-profile public face on energy innovation research. This could galvanize the support of policymakers and the public and help to ensure adequate funding for the important project of creating a clean energy future. Even the name of the institution, the National Institutes of Energy, connects the success of the NIH with the need for energy research in the public's and policymakers' minds.

CONCLUSION

While the United States has taken important steps toward transitioning to clean energy, we cannot reach our ultimate goal without new and affordable clean energy technologies. As President Obama and leading energy innovation experts recognize, this will require expanding the government's investment in research and development by $15 billion per year. To maximize this investment, we also need to model energy R&D on one of the federal government's most successful and popular institutions—the National Institutes of Health—by creating a National Institutes of Energy. Increased funding and the establishment of an NIE will help get America running on clean energy through the development of new, low-cost, and deployable clean energy technologies. Such a strategy is critical to secure America's economic competitiveness in the 21st century.

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THE AUTHORS

Josh Freed is Director of the Third Way Clean Energy initiative and can be reached at jfreed@thirdway.org. Avi Zevin is a Policy Advisor for the Third Way Clean Energy Initiative and can be reached at azevin@thirdway.org. Jesse Jenkins is Director of Energy and Climate Policy at The Breakthrough Institute and can be reached at jesse@thebreakthrough.org.

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The Breakthrough Institute is one of America's leading think tanks developing climate and energy policy solutions. Since 2002 Breakthrough has been a pioneering advocate of an innovation-centered approach to the nation's energy and climate challenges, calling for major federal investments to make clean and low-carbon energy technologies cheap and abundant, strengthen America's economic competitiveness and energy security, and slow global warming. For more information about The Breakthrough Institute please visit thebreakthrough.org.

ENDNOTES

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9 Energy Secretary Steven Chu has called for Nobel-level "breakthroughs" in at least three core energy technologies: advanced batteries for vehicles, new crops for biomass energy, and solar panels cheap enough to deploy without subsidy. Secretary Chu called for "a battery that's ten times better and cheaper than what we've got" and argued that a new "green revolution" was possible in the design of perennial crops that could provide a feedstock for affordable

and sustainable biomass energy and biofuels. On solar, Dr. Chu said: "There should be a new generation of photovoltaics. The photovoltaics we have today, if you say without subsidy, and without even the additional cost of storage, it's about a factor of five higher than electricity generation by gas or coal. Suppose someone comes along and invents a way of getting ... solar photovoltaics at one fifth the cost, so you don't even think about subsidies anymore. You just slap it everywhere... That, in my opinion, would take something, which I would say, is a bit of a breakthrough." Source: "Big Science Role Is Seen in Global Warming Cure." New York Times, February 11, 2009. Available at: http://www.nytimes.com/2009/02/12/us/politics/12chu.html?_r=2.

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26 Holdren, John P. "The Energy Innovation Imperative," Innovations, Spring 2006, at p. 20.

27 Scheyder, Ernest. "High-Powered Spending On Alternative Energy Tumbles." Associated Press, May 11, 2009. Available at: http://www.huffingtonpost.com/2009/05/11/high-powered-spending-on_n_201570.html.

28 Testimony of John Denniston of Perkins Caulfield, Senate Committee on Energy and Natural Resources, Hearing to Investigate Market Constraints on Large Investments in Advanced Energy Technologies, Senate Hearing 110–63, March 7,2007, p. 53. Available at: http://www.access.gpo.gov/congress/senate/senate08ch110.html.

29 Nathanial Gronewold. "Clean Tech Frets as Power of Government's Purse Grows." Greenwire. (June 25, 2009). Available at: http://www.nytimes.com/gwire/2009/06/25/25greenwire-clean-tech-frets-as-power-of-governments-purse-g-661.html.

30 Current venture capital investment is primarily focused on technologies that already receive significant government subsidies such as ethanol, solar, and wind, with significantly less support at real path-breaking research into new technology. Weiss, Charles and William Bonvillian. Structuring an Energy Technology Revolution. MIT Press. 2009. p. 128.

31 Kammen and Nemet 2007, p. 749.

32 Kammen and Nemet 2007 p 749.

33 Herzog, Antonia and Daniel Kammen. "Energy R&D: Investment Challenge." Materials Today: 5 (2002) p. 28-33

34 Graphic Source: Herzog, Antonia and Daniel Kammen. "Energy R&D: Investment Challenge." Materials Today: 5 (2002) p. 28-33

35 Newell, Richard G. "A U.S. Innovation Strategy for Climate Change Mitigation." The Hamilton Project, Brookings Institution (December 2008). p. 30.

36 "Department of Energy: Budget by Appropriation." Summary Tables by Appropriation. Available at: http://www.energy.gov/about/budget.htm.

37 Expressed as a relative percentage of GDP, the "Project Independence" energy R&D funding initiated after the Arab Oil Embargos would be the equivalent of $14 billion in today's economy. Newell 2008, p. 80.

38 Nemet and Kammen 2007 p. 752. Federal energy R&D reached a peak of $9 billion (in constant 2007 dollars) in the late 1970s. Expressed as a relative percentage of U.S. GDP, the "Project Independence" energy R&D investments initiated after the Arab Oil Embargos would represent a commitment of 0.1% of U.S. GDP, the equivalent of $14 billion in today's economy.

39 Breaking Through on Technology: Overcoming the barriers to the development and wide deployment of low-carbon technology. Center for American Progress and Global Climate Network. Available at: http://www.americanprogress.org/issues/2009/07/pdf/gcn_report.pdf.

40 Data source: Kammen and Nemet 2005 and Newell 2008. Manhattan Project: Peak year funding of $12 billion or 0.4% of GDP. Apollo Project: Peak year funding of $28 billion or 0.4% of

GDP. Project Independence: Peak year funding of $9 billion or 0.1% of GDP. Regan-era Defense R&D: Peak year funding of $67 billion or 1.8% of GDP. NIH: Peak year funding of $33 billion or 0.3% of GDP. All dollar values are 2007 real dollars and all percentages of GDP are percentage of peak year U.S. GDP.

41 President Obama has pledged to "Invest $150 billion over ten years in energy research and development to transition to a clean energy economy." See "Energy & Environment." WhiteHouse.gov. Available at: http://www.whitehouse.gov/issues/energy_and_environment/. In the President's 2010 budget outline, this $15 billion per year investment in R&D is shown as a new line-item, above and beyond the roughly $5.9 billion in Department of Energy energy-related funding projected in 2012, bringing total energy R&D funding to over $20 billion annually by 2012. See A New Era of Responsibility: Renewable America's Promise. U.S. Office of Management and Budget (February 2006). p 130. Available at http://budget.gov.

42 Revkin, Andrew C. "Science Adviser Lays Out Climate and Energy Plans." Dot Earth (New York Times), April 9, 2009. Available at: http://dotearth.blogs.nytimes.com/2009/04/09/science-adviser-lists-goals-on-climate-energy/.

43 Nemet and Kammen 2007 p. 752.

44 Duderstadt et al. 2009.

45 Breaking the Climate Deadlock – Technology for a Low Carbon Future. The Climate Group and the Office of Tony Blair (July 2009). p. 3. Available at: http://www.theclimategroup.org/about/publications

46 "34 U.S. Nobel Laureates Urge Inclusion of President Obama's $150 Billion Clean Energy Technology Fund in Climate Legislation." Federation of American Scientists (July 17, 2009). Available at: http://www.grist.org/article/2009-07-16-34-nobel-winners-write-president-about-climate-energy-bill/.

47 This new funding will greatly expand the scale of federal energy research activity and provide sufficient funding to channel R&D investments through multiple agencies, both new and already existing. "Just as competition in markets helps resolve uncertainties and improves economic performance, competition within government can improve performance in fostering innovation," notes technology and innovation policy expert John Alic. Lessons learned from U.S. experience with successful innovation policies reveals that rather than fostering waste, "[t]he messy and often duplicative structure of U.S. R&D support and related policies creates diversity and pluralism, fostering innovation by encouraging the exploration of many technological alternatives." Good ideas have more than one chance to find funding support in a system with multiple federal research agencies with somewhat overlapping and competing scope and missions, and policymakers are able to better evaluate the performance of individual programs—rewarding high performers with additional funding, while scaling back wasteful, inefficient, or out-of-touch programs. See Alic, John et al. U.S. technology and innovation policies: Lessons for Climate Change. Pew Center on Global Climate Change (November 2003). pps. 4 and 43. We recommend that the federal government use expanded clean energy R&D funding, to the extent possible, to establish a new National Institutes of Energy, as discussed in detail in section two. Additional funding should augment the most effective existing programs within the Department of Energy and other federal agencies engaged in energy-related research, including the Departments of Commerce, Defense, Agriculture, and Transportation and the National Science Foundation, taking advantage of existing infrastructure, staff and expertise. Such programs may include the DOE's Office of Science and Offices of Energy Efficiency and Renewable Energy, the Small Business and Innovation Research and Small Business Technology Transfer grant programs run by the Small Business Administration and DOE, and the Technology Innovation Program and Manufacturing Extension Program, both run by the Department of Commerce. Funding should also support new or recently established, innovative paradigms for energy research, including ramp-up of the new Advanced Research Projects Agency for Energy (ARPA-E), the DOE Energy

Frontier Research Centers program, and proposed DOE energy innovation hubs at each of the existing DOE applied research offices.

48 Atomic energy defense-related activities made up 63 percent of the total FY2008 DOE budget and 48 percent of the FY2009 budget. In contrast, energy innovation-related activities made up just 17 percent of the total FY2008 DOE budget and 16 percent of the FY2009 budget. See "Department of Energy: Budget by Appropriation." Summary Tables by Appropriation. Available at: http://www.energy.gov/about/budget.htm.

49 The network of National Labs focuses largely on high-energy particle physics, nuclear physics, and a wide range of basic science activities designed to further human understanding, not on the development of commercializable innovations. Furthermore, due largely to their legacy as part of the national defense research apparatus, many DOE laboratories have inherited an insular culture and are often too far removed from the needs of the marketplace and the innovation and talent residing in the nation's high-caliber private sector firms and research universities. Notable exceptions exist, and offer potential models for reform of DOE institutions, such as the Energy Biosciences Institute, a recently established renewable energy research consortium involving Lawrence Berkeley National Laboratory, the University of California, Berkeley, the University of Illinois at Champaign Urbana, and the oil company, BP.

50 Statement of Steven Chu Secretary, U.S. Department of Energy Before the Senate Committee on Appropriations Subcommittee on Energy and Water Development, and Related Agencies Statement of Steven Chu Secretary, U.S. Department of Energy Before the Senate Committee on Appropriations Subcommittee on Energy and Water Development, and Related Agencies. FY 2010 Appropriations Hearing, May 19, 2009. Available at: http://www.congressional.energy.gov/documents/5-19-09_Final_Testimony_(Chu).pdf.

51 The American Clean Energy and Security Act (H.R. 2454): Section-by-Section Summary. Committee on Energy and Commerce (July 14, 2009). p. 6. Available at: http://energycommerce.house.gov/Press_111/20090720/hr2454_sectionsummary.pdf.

52 Getting America Running on Clean Energy: Findings from National Focus Groups. Third Way. (2009). Available at: http://thirdway.org/products/218.

53 Initial funding for the program would ideally fund half a dozen institutes in diverse regions of the country and scale to more and larger institutes over time as the NIE is successful.

54 NIH's Office of the Director (OD) has established a clear process for identifying, reviewing and establishing goals and special initiatives, allowing it to focus the institutes on areas where collaboration between research institutes is necessary. This process relies heavily on consultation with scientific and public constituencies through advisory committees in order to determine and set goals. The OD has struck a healthy balance between managing institutes and centers and providing them with enough autonomy to establish their own projects and special initiatives.

55 Enhancing the Vitality of the National Institutes of Health: Organizational Change to Meet the New Challenges. National Academy of Sciences (2003). p. 10. Available at: http://www.nap.edu/catalog.php?record_id=10779.

56 Weiss and Bonvillion 2009, p. 173.

57 Brooking's recent and important e-DII proposal, for example emphasizes the importance of decentralization but lacks important institutions for coordinatation among and across institutes, while the newly created ARPA-E institution relies too heavily on centralized contracting without the benefits of a regional, decentralized system.

58 Hamilton Moses III et al. "Financial Anatomy of Biomedical Research." JAMA, 2005;294, Pg 1333-1342.

59 This regional component draws on the recommendations of the Brookings Institute's 2009 report, Energy Discovery Innovation Institutes: A Step Toward America's Energy Sustainability.

60 Like with NIH, new technologies developed through NIE funding will be subject to a variety of intellectual property restrictions, depending on the entity that made the technological developments. In the case of research conducted in-house at the federal agency, or research conducted jointly by the federal agency and a larger business or another government entity, the government retains intellectual property rights and can (and does) negotiate license agreements that provide for royalty payments. In the case of small businesses, universities, and other non-profits, the government retains no intellectual property interest in the research conducted by such institutions, and therefore may not collect any royalties from any arrangements to license the results of their federally funded research.

61 Harris Interactive Inc. "CDC, FAA, NIH, FDA, FBI and USDA Get the Highest Ratings of Thirteen Federal Government Agencies." PRNewswire (February 6, 2007) Available at: http://www.prnewswire.com/cgi-bin/stories.pl?ACCT=109&STORY=/www/story/02-06-2007/0004521666&EDATE.

62 Scientific Achievements Less Prominent Than a Decade Ago: PUBLIC PRAISES SCIENCE; SCIENTISTS FAULT PUBLIC, MEDIA. Pew Research Center for the People & the Press (July 9, 2009). Available at: http://people-press.org/report/528/.

63 Global Warming's Six Americas: An Audience Segmentation Analysis. Yale Project on the Climate Change and George Mason University Center for Climate Change Communication (May 20, 2009). p. 93. Available at: http://www.americanprogress.org/issues/2009/05/pdf/6americas.pdf.

64 Enhancing the Vitality of the National Institutes of Health: Organizational Change to Meet the New Challenges. National Academy of Sciences (2003). p. 18. Available at: http://www.nap.edu/catalog.php?record_id=10779.

65 "Summary of the FY 2009 President's Budget." National Institutes of Health (Feb. 4, 2008), Available at: http://officeofbudget.od.nih.gov/ui/2008/Summary%20of%20FY%202009%20Budget-Press%20Release.pdf.