Strengthening Clean Energy Competitiveness

Opportunities for America COMPETES Reauthorization

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Introduction

Accelerating U.S. clean energy innovation, manufacturing, and commercialization is an environmental necessity. Without new innovations and a robust clean energy technology policy, the United States will not be able to reduce greenhouse gas emissions (GHG) to needed levels, unless the price of GHGs rises to politically unsustainable levels.[1] As important as these environmental objectives are, clean energy innovation is also an economic imperative. Investments in the global clean energy industry are expected to grow 25 percent to $200 billion in 2010[2] and are predicted to reach $600 billion by 2020.[3] Government policy and public investment will be critical determinants of which countries become leaders in the race to attract that clean energy technology investment and the economic and job creation benefits these investments will bring.

Unfortunately, the United States is lagging behind in this race, in part because it lacks an effective strategy to compete. Even if proposed carbon trading legislation becomes law, the resulting price on carbon will be too low and accompanying efficiency and renewable energy regulations will not be sufficient on their own to ensure that the United States catches up to countries like China in building the clean energy industries of the future.[4] To regain leadership in the global clean energy industry, the United States must prioritize major public investments in clean energy technology and embrace bold new paradigms in clean energy innovation, education, production, and manufacturing.[5]

To this end, the reauthorization of the America COMPETES Act offers a critical opportunity to both strengthen and update U.S. clean energy innovation and competitiveness policies. Meeting this challenge, however, will require more than just an increase in funding for existing programs, as critical as these investments are. It will also require re-thinking how the federal government can foster innovation in the clean energy industry, from basic research to full-scale commercialization.

Along these lines, this report offers a number of recommendations organized around three guiding themes:

1. Increasing the scale of investment in clean energy education, research and innovation, and production and manufacturing;
2. Funding innovative programs that offer new institutional paradigms for accelerating the pace of clean energy innovation; and
3. Effectively leveraging federal investments by fostering coordination between existing and new clean energy innovation programs to spur regional public-private collaboration, strengthen clean energy industry clusters, and accelerate technology innovation, manufacturing, and commercialization.

Summary of Recommendations

With these three themes in mind, this report recommends that Congress, through the America COMPETES reauthorization, strengthen or include provisions in four key areas:

1 Clean Energy Science and Engineering Education

- Authorize a suite of programs to train a new generation of energy scientists, engineers and innovators, with a funding scale-up over the course of five years to $470 million annually. Funding should be provided for the development of curriculum, educational programs, and research opportunities in energy related science, technology, engineering, mathematics, and interdisciplinary "energy studies" at universities around the country, as well as for undergraduate financial aid, graduate fellowships, and post-doctoral research awards.

2 Clean Energy Research and Innovation

- Ensure the reauthorization and appropriation of a scheduled doubling in research budgets for critical science and technology agencies, including the Department of Energy (DOE) Office of Science, the National Science Foundation (NSF), and the National Institute of Standards and Technology (NIST). Programs focused on energy sciences and technology should be prioritized.
- As part of the doubling of the DOE Office of Science budget, Congress should authorize a doubling in funding for DOE's Energy Frontier Research Centers (EFRCs) to $300 million by FY2014.
- Authorize a steady scale-up of funding for the Advanced Research Projects Agency for Energy (ARPA-E) over the next five years to $1.5 billion annually, putting the agency on track to potentially reach $3 billion per year in ten years time – a funding level on par with current DARPA budgets and at a scale necessary to truly impact the pace of innovation in the expected multi-trillion dollar clean energy market.[6]
- Authorize $200 million in annual funding over five years to fully support the eight proposed DOE Energy Innovation Hubs.
- While we understand that the scope of COMPETES does not include tax policy, we believe that any clean energy innovation policy needs to include a more robust R&D tax credit.

3 Advanced Clean Energy Production and Manufacturing

- Establish a new national innovation institute to help the nation's most energy and carbon-intensive manufacturing sectors become more efficient and reduce emissions.
- Create a new domestic clean energy supply chain initiative at the Hollings Manufacturing Extension Partnership (MEP) and expand funding for the MEP to $400 million annually in five years time.
- Authorize $15 billion in federal grants to capitalize state-run revolving loan funds to increase access to low-cost capital to help American manufacturers retool to produce clean energy products and adopt advanced clean energy production techniques.
- While also beyond the scope of the COMPETES reauthorization, we support an extension of the 48C tax credit for advanced energy manufacturing as a component of a comprehensive clean energy competitiveness strategy.

4 Clean Energy Industry Clusters

- Authorize and fund an explicit clean energy industry growth strategy based on regional energy industry cluster initiatives administered through the Economic Development Administration (EDA). Cluster initiatives should leverage existing federal, state, and private resources and coordinate clean energy research and innovation, production, and market deployment activities to speed the development and commercialization of new clean energy technology products.
- Create a pilot program to fund and support collaborative, public-private clean energy research consortia that can act as anchors for competitive regional industry clusters and sectoral networks.
- Create a Federal Clean Energy Innovation Council to facilitate institutional coordination between regional clean energy industry clusters and federal programs supporting clean energy innovation, production, and commercialization activities.

In an era of rising deficits, a responsible strategy to put the United States on a sound fiscal footing must differentiate between government spending (some of which is certainly wasteful), and productive public investments that yield long-term economic benefits. While some may view the recommendations in this report as an unnecessary contribution to a growing federal deficit, the long history of federal investment in technology and education shows that this assumption is incorrect. For example, every dollar invested in education by the GI bill following World War II returned just over $5 in greater economic growth and $1.83 in greater tax revenues over the following 35 years, according to a Congressional report.[7]

Likewise, federal investment in R&D is a key driver of productivity gains and economic growth, and studies routinely conclude that there is a significant rate of return on such investments for both the national economy and the federal tax base.[8] For example, one study of a sample of research projects funded by NIST demonstrated a median rate of return of 144 percent.[9]

Moreover, the budget deficit is not the only debt that future generations of Americans will have to repay. If deficits in trade also continue to mount, at some future point the United States must run sustained trade surpluses in order to pay down foreign debt. Investing in clean energy innovation and enhancing American competitiveness in this growing, export-oriented sector may therefore present a key opportunity to balance the national trade deficit by helping the United States run trade surpluses in the clean energy sector.

Far from contributing to the nation's debt, investments in education, technology innovation, and competitiveness are therefore an essential component of any responsible and effective strategy to reduce the federal budget deficit, restore a trade balance, and return America to an era of sustained economic growth.

Challenges to U.S. Clean Energy Competitiveness

There are many challenges to the development of a robust clean energy technology industry in the United States, particularly as other nations move aggressively to compete for global clean energy markets. These challenges are summarized below:

A Perilous Lead in Clean Energy Innovation

The United States faces broad challenges in its innovation system. The recent Information Technology and Innovation Foundation (ITIF) report, "Atlantic Century," ranked the United States sixth out of 40 countries in innovation capacity and internal competitiveness, but dead last among the 40 nations in the rate of improvement over the last decade.[10] Meanwhile, China ranked first in rate of improvement, just one among several nations investing heavily to make rapid gains in innovation capacity.[11] In other words, having already ceded the lead in innovation, the U.S. position relative to other nations will only continue to deteriorate unless Congress takes concrete steps to regain an innovative edge.

America's lead in next generation clean energy technologies is tenuous at best. Although the United States invented many of the clean energy technologies in wide application today – including nuclear, wind, and solar power – clean energy innovation is now global, with other

countries competitively investing in next generation clean technology R&D. The United States is only slightly ahead of Japan in clean energy patents and government investment in energy R&D, yet as a percentage of GDP, the governments of Japan and South Korea actually outspend the United States on energy innovation two-to-one.[12] U.S. private sector energy R&D spending is minuscule, accounting for less than one half of one percent of industry revenues – one tenth of the nation-wide industry average and two orders of magnitude less than innovation-intensive industries like IT or biomedical technology.[13] In fact, U.S. firms are even moving state-of-the-art energy research operations overseas.[14] Thus, increased U.S. public investment in clean energy R&D is necessary to fill the innovation gap and secure America's leadership in clean energy innovation.

Losing Out in Clean Energy Production

The United States also lags behind its economic competitors in the growing race to commercialize and manufacture clean energy technologies. The Breakthrough Institute and ITIF report, "Rising Tigers, Sleeping Giant," documents that China, Japan, and South Korea have collectively surpassed the United States in the production of virtually all clean energy technologies, from solar and wind energy, to nuclear power, high-speed rail, and advanced vehicles and the batteries that power them.[15]

Job creation has become a top concern among policymakers, and recent studies indicate that a large portion of clean energy jobs are created in the design and manufacturing stages of the value chain. For example, 70 percent of the jobs associated with wind energy deployment are created in manufacturing, with only 30 percent created in installation and maintenance.[16] Yet clean energy manufacturing continues to move overseas, threatening the growth of a critical industry that could contribute to the nation's economic recovery.[17]

A Competitive Education Gap

On a host of science, technology, engineering, and math (STEM) education metrics, America is falling behind its economic competitors. The United States ranks just 29th out of 109 countries in the percentage of 24 year-olds with a math or science degree.[18] Only 15 percent of undergraduate degrees in the United States are earned in STEM fields compared with 64 percent in Japan and 52 percent in China.[19] Even South Korea – a nation with a population one-sixth the size of the United States – graduates more engineers annually.[20]

The situation is particularly dire in energy technology. The U.S. energy industry expects up to half of its current employees to retire over the next five to ten years, while the demand for workers in the renewable electricity industry is expected to more than triple from 127,000 in 2006 to more than 400,000 in 2018.[21] The anticipated, large-scale ramp-up of the U.S. nuclear

power industry would similarly require the industry to hire tens of thousands of new nuclear engineers and related positions annually. Yet the large majority of U.S. colleges and universities lack degree programs focused on energy. According to the DOE, "at all levels, from elementary school to post-doctorate programs ... students and educators do not have the resources to develop curricula, educational programs, and research opportunities to meet this need."[22]

Growing Trade Deficits

Given the weakness in clean energy innovation, production, and education, it should be no surprise that the United States is running a trade deficit in this sector. In the last five years, the U.S. trade deficit in renewable energy products increased by 1,400 percent to nearly $6 billion.[23] Although clean energy export opportunities are critical to creating millions of clean energy jobs and helping to drive the nation's economic recovery, the United States faces declining export market shares in virtually every regional market. At the same time, the United States has become the world's largest import market for clean energy technologies and was the fastest growing import market from 2004-2008, when measured by product value.[24] The clean energy trade deficit represents a visible manifestation of America's decline in innovation-based competitiveness.

The Purpose and Intent of America COMPETES

Passed in 2007, the America COMPETES Act was a response to mounting concern that the United States was losing its ability to effectively compete economically with other nations.[25] The Act authorized a number of new initiatives and funding for various programs, particularly for science, research, and STEM education, including a doubling of the research budgets of three critical science and technology agencies over seven years time: the DOE Office of Science, NSF, and NIST.

It is important to recognize, however, that many of the authorized increases for programs in these key federal innovation agencies have not been appropriated, and thus, several programs important to America's technological competitiveness remain underfunded relative to their authorized increases. At the same time, competitive pressures in the global economy have continued to grow, particularly in the rapidly expanding clean energy industry, while new insights and realities have altered the state of the art in innovation policy. Therefore, the Act's reauthorization represents a key opportunity for Congress to reaffirm the government's commitment to science and technology in general, and to expand the Act to address new and unfolding challenges in energy sciences and the burgeoning clean energy industry.

America COMPETES Opportunities for Clean Energy Competitiveness

In reauthorizing the America COMPETES Act, Congress has a critical chance to enact several important measures to strengthen U.S. clean energy competitiveness in the face of aggressive competition from abroad. These measures include: investing in a new generation of clean energy scientists and engineers; increasing funding for clean energy R&D at existing agencies and in new innovative programs; and supporting American clean energy manufacturers. While increasing funding in each of these areas will be critical, there is also a significant need to foster institutional innovation throughout the federal clean energy innovation system to better coordinate resources, effectively leverage federal dollars, and spur public-private collaboration to accelerate technology commercialization. Moreover, an increasing amount of research has identified regions as effective delivery mechanisms for such coordination. Congress should therefore create and fund regional clean energy industry cluster initiatives as an essential step in strengthening the overall federal energy innovation and commercialization system. Each of these key measures is discussed below.

Clean Energy Science and Engineering Education

There is a clear national need to train and inspire the next generation of intrepid American scientists, engineers, and entrepreneurs to meet the nation's energy innovation challenges. If the United States is to continue its role as a pioneering innovator and global technology leader, the federal government must make substantial investments in science, technology, engineering and math education (STEM). Given the strategic importance of our clean energy industry, Congress should consider education in clean energy fields to be a significant national priority.

The Obama Administration has introduced the first major national initiative designed specifically to address clean energy STEM education. The proposed RE-ENERGYSE initiative, a strategic partnership between DOE and NSF, is seeking $74 million in appropriations for FY2011.[26] Congress should use the COMPETES reauthorization to authorize the FY2011 request for this critically important program.

While RE-ENERGYSE is a critical first step, a much larger national educational investment program will ultimately be necessary to ensure the availability of the trained and highly skilled workforce needed to accelerate clean energy innovation and secure America's clean energy competitiveness. The historical corollary should be the investments made under the National Defense Education Act (NDEA) of 1958, which was critical in establishing university programs in computer science, aerospace, and other new fields across the nation as well as

training the generation of innovators and entrepreneurs that led the IT revolution. The NDEA directed $1.8 billion annually over four years (in today's dollars)[27] to expand support for students entering critical science and math fields, expand student loans, and build K-12 through graduate-level curricula in science and technology. In all, NDEA helped send nearly 250,000 students to college on federal loans by 1964.[28]

To secure America's clean energy competitiveness far into the future, the U.S. government must invest more ambitiously in clean energy education. We recommend a program scaling over the next five years to $470 million in total funding per year, including:

- $40 million for the development of clean energy curricula, educational programs and research opportunities at undergraduate and graduate institutions across the country.[29] Funding would also help establish and support new professional masters degree programs in interdisciplinary "Energy Studies" and "Professional Energy Sciences" or similar programs.[30]
- $200 million to provide competitive financial aid, including scholarships, federal subsidized loans, or loan forgiveness, sufficient to support at least 10,000 undergraduate students per year entering STEM fields.[31] Students receiving these awards could apply for competitive summer internship placements with universities, companies, and DOE offices and National Laboratories focused on clean energy science, technology, and policy.[32]
- $180 million to provide competitive, portable, three-year graduate fellowships for at least 3,000 graduates annually in energy engineering, science, and related research fields. NSF and DOE's Offices of Science, Energy Efficiency and Renewable Energy, and Nuclear Energy could jointly administer these fellowship programs.[33]
- $50 million to provide post-doctorate research awards to support at least 330 early-career researchers in cutting-edge, clean energy related science and innovation fields.[34]

Clean Energy Research and Innovation

To ensure that America remains a leader in clean energy innovation, Congress should strengthen the federal energy innovation system by increasing funding for federal energy R&D activities and supporting several innovative new energy research programs. We recommend the following:

Double Clean Energy R&D Budgets for Critical Science and Technology Agencies

Congress should reauthorize a doubling (from 2006 levels) of the research budgets for the DOE Office of Science, NSF, and NIST by 2013. The Obama Administration's proposed budget would double funding for these agencies over ten years from 2006-2016, which differs from the seven year doubling path originally authorized by COMPETES.[35]

Given the increasing importance of the global clean energy industry and America's lagging position in the clean energy race, we recommend that a growing share of Office of Science budget increases be directed toward clean energy technology research and applications.[36] Funding for clean energy programs at NSF and NIST should also be increased. For example, NSF should expand funding for its multidisciplinary Engineering Research Centers (ERCs) with a clean energy related focus.[37] Congress should also charge NIST's Technology Innovation Program (TIP) with using a significant share of increased funds for clean energy research.

Expand Funding for Energy Frontier Research Centers

Energy Frontier Research Centers (EFRCs) – a program within DOE's Office of Basic Energy Science – fund small, collaborative groups of researchers working to unlock breakthroughs that solve the specific scientific problems blocking clean energy development. Such "use-inspired" basic research is critical to unlocking new technology pathways to make clean energy more reliable and affordable.[38]

Increased funding for EFRCs should be a key component of the doubling of the DOE Office of Science budget proposed above. We recommend that funding levels for EFRCs be doubled from current levels of about $155 million in annual project support awarded in FY2009[39] to at least $300 million per year by FY2013.[40] This funding would be sufficient to support 60-150 EFRC projects ongoing at any given time and capable of catalyzing cutting-edge research at the frontier of energy sciences.

Increase Budget for the Advanced Research Projects Agency for Energy

The Advanced Research Projects Agency for Energy (ARPA-E) funds researchers in the public or private sector focused on high-risk, high-reward breakthroughs in energy technology. The program uses an entrepreneurial funding model to support specific new technologies where short-term R&D support could deliver game-changing results. The new agency is modeled after the Defense Advanced Research Projects Agency (DARPA), which drove rapid technological innovation and invented critical technologies in ubiquitous use today, including the Internet and GPS. ARPA-E was first appropriated with $400 million in the American Recovery and Reinvestment Act (for use in FY2009 and FY2010), and the Obama Administration requested $300 million in the FY2011 budget.

The ARPA-E program is critical to securing American clean energy competitiveness by developing a new generation of affordable technologies that can form the basis for a new export-oriented clean energy growth strategy. But the funding level for this innovative program remains far too small to keep up with either our economic competitors or the scale of need. Congress should work to increase ARPA-E's budget to $1.5 billion in five years, and $3 billion in ten years. Funding at this level would eventually bring ARPA-E to the same scale at which DARPA is funded today. Given the expected multi-trillion dollar scale of the clean energy industry,[41] only funding levels of this order of magnitude will spur the pace of innovation and entrepreneurialism necessary in the clean energy industry. America COMPETES offers a prime opportunity to increase the funding authorization for this critical energy innovation and competitiveness program.

Expand the Number of Energy Innovation Hubs

The DOE has also proposed eight Energy Innovation Hubs – large, collaborative teams of scientists and engineers that work together over a longer time frame to achieve goals for specific topics, such as dramatically cheaper solar energy, advanced nuclear power, and new battery chemistries with game-changing improvements in energy storage density. These Hubs are modeled after historical examples of effective, mission-oriented research efforts such as the Manhattan Project or AT&T's Bell Labs (which created the first transistor, among dozens of other breakthrough innovations), while incorporating state-of-the-art thinking about innovation pathways in the energy sciences.[42]

The Energy Innovation Hubs are critical for leveraging multi-disciplinary expertise in pursuit of transformational energy breakthroughs. Congress authorized and appropriated three Hubs in the FY2010 budget.[43] We recommend that Congress increase authorization to expand the

number of Energy Innovation Hubs to the originally requested eight and provide $25 million per hub per year, for a total of $200 million annually over five years.[44]

Expand the R&D Tax Credit

While we understand that the scope of COMPETES does not include tax policy, we believe that any clean energy innovation policy needs to include a more robust R&D tax credit, both generally and specifically targeted to clean energy. Toward that end the Alternative Simplified Credit should be expanded from its current level of 14 percent to 20 percent.[45] In addition, the R&D tax credit (established as section 1351 in the 2005 Energy Policy Act) to support energy research consortia (including clean energy research centers at universities and federal labs) should be expanded from its current rate of 20 percent to 40 percent.[46]

Advanced Clean Energy Production and Manufacturing

Despite decline in recent years, manufacturing remains a critically important sector of the U.S. economy. U.S. manufacturing firms employ 13 million workers, represent two-thirds of total U.S. research and development investment, and account for more than 80 percent of U.S. exports.[47] While developing a globally competitive manufacturing sector is important in general, it is especially so in the fast-growing clean energy industry, which also offers a major new export opportunity. Without a competitive domestic clean energy manufacturing industry and strategy, the United States will continue to trade its dependence on foreign oil for dependence on foreign clean energy products.

The COMPETES Act offers an important opportunity to authorize programs that can increase the acceleration of manufacturing scale-up, the adoption of advanced manufacturing techniques, and the development of a robust clean energy manufacturing industry in the United States. These include:

Increase Manufacturing Extension Partnership Funding and Create a New Clean Energy Supply Chain Initiative

In order to be successful in the clean energy economy, the United States needs a robust innovation base, strong clean energy original equipment manufacturers, and efficient and innovative suppliers of clean energy inputs. One program that can help achieve this outcome is the Department of Commerce's Hollings Manufacturing Extension Partnership (MEP), which provides technical assistance to help small and medium-sized American manufacturers

adopt new technologies and improve productivity. In order to ensure that small firms are well positioned to be competitive suppliers, Congress should fund a new regional clean energy supply chain initiative through the MEP to support manufacturers in their diversification into new clean energy markets. This program should be closely coordinated with regional cluster initiatives to more readily incorporate new technology innovations arising from research and increase access to market information to accelerate technology commercialization.

Currently, the MEP is oversubscribed, and expanding the program's responsibilities in the clean energy industry will require additional funding. The House-passed American Clean Energy and Security Act (ACESA) included an authorization for a clean energy manufacturing supply chain initiative and increased the scale of the MEP program from $150 million today to $400 million annually.[48] We recommend that Congress authorize a similar level of funding in America COMPETES, steadily expanding MEP funding to $400 million per year in five years time, ensuring sufficient funds to fully service existing MEP centers and support the new clean energy supply chain initiative.

Provide State-Based, Low-cost Financing for Advanced Clean Energy Manufacturing

One of the major barriers to the establishment of a domestic clean energy manufacturing industry is access to capital, which is critical for any manufacturer wishing to expand its operations or retool to produce clean technologies. Largely as a result of the recession, manufacturers, particularly small and medium-sized companies, continue to face a reduction in demand and difficulty in securing the needed credit. As other nations move aggressively to develop domestic clean energy industries and demand for clean energy continues apace, the ability of U.S. manufacturers to retool quickly to take advantage of new export opportunities in clean technologies will be a major determinant of future success.

Therefore, Congress should allocate $15 billion to the Department of Commerce (DOC) for a new grant program to provide capitalization for state-managed revolving loan funds that provide low-cost financing for the retooling or expansion of clean energy production facilities and the adoption of advanced clean energy production techniques. The focus should be on facilities capable of producing commercially viable clean energy technologies for which there is (or is expected to be) a large or growing global demand.[49] To effectively leverage federal dollars, state governments should contribute at least one dollar of their own funding for every dollar of federal funds. The loan program should also require state-coordinated plans that foster regional cluster initiatives building on public-private collaboration and coordination of innovation, production, and commercialization activities.

Establish a National Institute on Energy Innovation in Energy-Intensive Manufacturing

Approximately one-third of U.S. GHG emissions are from manufacturing, with the lion's share from energy-intensive sectors such as chemicals, pulp and paper, primary metals, glass, and cement. If we expect to reduce GHG emissions in the United States without raising costs for these industries so much that they move facilities offshore, we will need to develop the next generation of energy-efficient industrial processes. However, because companies cannot capture most of the benefits of such innovations, they under-invest in these technologies. Moreover, there has been insufficient federal policy focus on the challenges faced by these industries. To remedy this oversight, Congress should establish a national institute organized as a Federally Funded R&D Center to invest in process R&D that improves industrial competitiveness and reduces energy use and emissions in our most energy and carbon-intensive industries. The Center should bring together researchers from industry, academia, and federal laboratories to develop the next generation of energy efficient technologies and low-carbon process innovations for these industries. Federal funds would be matched by industry funds.[50]

Extend the 48C Advanced Energy Manufacturing Tax Credit

Again, while we recognize that tax policy is outside the scope of the America COMPETES reauthorization, we also support continuation and expansion of the 48C tax credit for clean energy manufacturing as part of a comprehensive suite of clean energy competitiveness policies. In addition, we recommend several changes to the award criteria, including greater focus on projects involving innovative clean energy technologies with the greatest potential to achieve significant, cost-effective reductions in GHG emissions and bolster U.S. exports (e.g., next-generation solar power technologies, modular nuclear reactors, or advanced vehicle batteries; see endnote for more).[51]

Clean Energy Industry Clusters

In all of these ways, the United States must strengthen the innovation process as it takes place across the entire clean energy technology pipeline, from R&D to technology commercialization. Too often, though, it is assumed that basic research is effortlessly translated into commercial activity. Unfortunately, commercialization does not happen so easily. Instead, the commercialization process is characterized by major complications, including information breakdowns, institutional inertia, coordination and communication problems, and poorly aligned incentives. Adding to these complications is the more recent disaggregation of the development system due to the globalization of the supply chain.[52]

Fortunately, scholarly research has identified strategies that strengthen and energize local "industry clusters" as an innovative way to link and align existing assets at the regional level to help overcome these challenges and accelerate technology commercialization.[53] Regional industry clusters are functional innovation "ecosystems" within which inventors, investors, manufacturers, suppliers, and universities, as well as local and state government officials interact and may establish dense, productive networks of relationships.[54] These networks create cost and innovation advantages for cluster participants by facilitating information exchange, access to high-caliber human capital, and R&D collaboration. More broadly, clusters provide a milieu within which all sorts of exchanges can transpire that accelerate the pace of innovation, from R&D to commercialization, while conferring lasting competitive advantage.[55]

The Obama Administration has embraced the logic of industry clusters in its FY2011 budget, including a $75 million request for the Regional Innovation Clusters program at the DOC's Economic Development Administration (EDA).[56] Programs like these represent a new paradigm for federal economic development and technology innovation and commercialization activities and should be supported by Congress. Furthermore, as clean energy is a clear strategic industry for the future of the U.S. economy, industry clusters designed specifically around clean energy technology are necessary to accelerate clean energy innovation, production, and commercialization and regain U.S. clean energy leadership.[57]

▸ Provide Grants to Support Clean Energy Industry Clusters

Along these lines, we recommend that Congress authorize the creation of a grant program to support regional clean energy industry cluster initiatives. The program should be administered by the EDA, and projects should be originated at a regional level, since regions are best equipped to maximize the economic impact of new clean energy investments via local innovation networks, supply chain relationships, and key education and research institutions.

This program should be integrated as much as possible with existing clean energy innovation, production, and commercialization programs, so as to maximize coordination among existing assets. In this regard, the new Energy Regional Innovation Cluster (E-RIC) provides an example of the type of effort needed to connect and coordinate federal, state, and private-sector resources and catalyze clean energy innovation at a regional level. The program is a joint funding opportunity involving seven federal agencies that will integrate a new DOE Energy Innovation Hub focused on energy efficient building systems into a broader regional economic development paradigm linked with federal and non-federal investments in business development, infrastructure, and education.[58]

Along these lines, we recommend the establishment of a similar, long-term program managed by the EDA, which would award competitive grants to regional organizations to support cluster initiatives involving such actors as businesses, trade associations, universities, economic development organizations, and local and state governments. Such initiatives would facilitate public-private collaboration and support the development of industry clusters around various clean energy technologies. Award selections should be based on the following criteria:

- Effective participation of a variety of critical actors, including universities, public and private research institutions, private companies and investors, and local and state governments;
- Ability to leverage state and private sector funding with other current federal energy related programs focused on use-inspired basic research, translational R&D, proof of concept, early commercialization activities, and production innovation and supply chain initiatives; and
- Responsiveness to regional needs and ability to capitalize on the particular strengths and capabilities of each region.

Grants of up to $5 million per year should be awarded to each clean energy technology industry cluster initiative for a time period not exceeding five years. Congress should authorize $75 million annually for the new program, which would be sufficient to stimulate at least 15 clean energy industry clusters around the country. To leverage federal dollars as much as possible, non-federal participants should be required to provide not less than 50 percent of the grant total to qualify for federal funding through the program. Congress should therefore expand authorized funding for the EDA to $150 million per year, including the FY2011 request for the existing Regional Innovation Clusters program, to provide sufficient funds to administer this critical new clean energy clusters program.

Create a Pilot Program to Fund Clean Energy Research Consortia

To support the development of effective clean energy clusters, new institutional paradigms should be employed to support collaborative, public-private research consortia that can act as anchors for competitive regional industry clusters and sectoral networks.[59] In particular, new institutional structures are needed to bridge the translational research gap between university basic research with a longer-term focus and private sector R&D with a near-term, commercially-oriented focus. Cross-disciplinary, multi-sectoral, clean energy research consortia can effectively leverage the expertise of university, governmental, and private sector research communities, as well as technology manufacturers, venture capital, and other participants in energy innovation to support commercially-applicable R&D and early-stage commercialization activities in areas not being served by the private sector. Such consortia will also help accelerate the growth of clean energy companies and regional jobs by catalyzing the growth of the entire energy innovation value chain from research through venture formation while spurring regional market and cluster development.

Therefore, Congress should authorize and fund a pilot program to create several public-private clean energy innovation consortia to spur collaborative research among key entities and effectively translate new innovations into commercial applications. This program should be established by the Secretary of Energy and should make grants of $10-30 million annually for up to three years to three or more consortia. Eligible consortia should consist of two or more research universities or governmental research facilities and at least three other private sector firms engaged in research, development, or commercialization activities.[60] Consortia must enter into an agreement to perform collaborative translational research activities focused around a key technical theme (e.g., more efficient, affordable solar cells). Applicants should be selected based on the following criteria:

- Ability to establish or strengthen a new or existing regional industry cluster;
- Capability to perform breakthrough research and efficiently translate new innovations into commercial applications; and
- Portion of non-federal funding provided by consortium participants.

Furthermore, since this is a pilot program, if three or more consortia are funded, at least one should be selected based on the ability of participants to strengthen key ties across an industry sector, rather than within a geographically focused regional cluster. This sectoral consortium pilot can evaluate the ability of distributed innovation networks to effectively accelerate translational research and commercialization activities.

Congress should support this pilot clean energy research consortia program in the reauthorization of America COMPETES to explore the potential for the expanded application of this new model to effectively catalyze collaborative clean energy research and commercialization activities as well as help anchor and strengthen key ties, both regional and sectoral, across the U.S. clean energy industry.[61]

Create a Federal Clean Energy Innovation Council

To facilitate institutional coordination among regional clean energy industry clusters and existing federal programs supporting clean energy innovation, production, and commercialization activities, we recommend the creation of a Federal Clean Energy Innovation Council, composed of high-level representatives of the DOE, DOC, NSF, the White House Office of Science and Technology Policy, and representatives of regional industry cluster efforts. The council should develop criteria that ensure existing federal programs are leveraged effectively by integrating with regional clean energy industry clusters. These programs include: energy science and research grants awarded by DOE, NSF, and NIST; awards to establish Energy Frontier Research Centers and Energy Innovation Hubs; MEP programs; and other related programs. Where appropriate or necessary, the America COMPETES reauthorization should include amendments to authorizing language that require federal programs to utilize the council's criteria in judging award applications. The council would also meet periodically to assess the performance of regional cluster programs, including a critical evaluation of the pilot regional and sectoral clean energy research consortia, and provide an open channel for cross-communication about regional cluster needs and national clean energy innovation, production, and commercialization priorities.

Conclusion

The reauthorization of the America COMPETES Act, a flagship effort to boost U.S. economic competitiveness, comes at a time when the United States faces major challenges in the global clean energy industry. Other nations are competing vigorously for new clean energy markets, and U.S. leadership in the industry has declined in recent years. The United States lags behind its economic rivals in STEM education to prepare a competitive energy workforce. The United States' historic lead in clean energy innovation is slipping as other countries implement national innovation strategies. And the country now lags economic competitors in Asia and Europe in the manufacture of virtually all clean energy technologies.

Given these challenges, and with the emergence of clean energy as a strategic global growth industry, the America COMPETES reauthorization offers a critical opportunity to reaffirm America's commitment to innovation and economic leadership in this key industry. Congress can help secure America's clean energy competitiveness by:

1. Increasing the scale of funding for clean energy education, research and innovation, and production and manufacturing activities;
2. Directing greater funding to new innovative models for federal innovation funding, such as EFRCs, Energy Innovation Hubs, and ARPA-E; and
3. Effectively leveraging federal resources by developing a national innovation system built on regional networks of clean energy industry clusters to enhance collaboration, accelerate technology commercialization, and maximize the economic impact of new clean energy investments.

We recognize that sources of funding for the initiatives we recommend authorizing in America COMPETES must be identified. We believe there are a number of sources of revenue that could be applied to the critical clean energy competitiveness programs we outline here, including sunsetting existing subsidies for mature energy technologies such as fossil fuels or dedicating new revenues from carbon permits or fees, an electricity wires charge for energy modernization, or federal revenues from oil and gas production.

It is also important to recognize, however, that returning the federal budget to long-term solvency will require smart public investments today to strengthen U.S. competitiveness in emerging industries and lay the foundation for economic growth. Thus, it is precisely because of our difficult fiscal situation that the investments outlined in this report are a critical priority. By re-thinking how the federal government can foster innovation and competitiveness in the American clean energy industry, from education and research to commercialization and production, the United States can once again become a global leader in the growing clean energy industry.

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About the Breakthrough Institute

The Breakthrough Institute is a leading, independent think tank developing climate and energy policy solutions for America and the world. Since 2002, Breakthrough has been a pioneering advocate of an innovation-centered approach to national and global 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 http://thebreakthrough.org.

About the Information Technology and Innovation Foundation

The Information Technology and Innovation Foundation (ITIF) is a non-partisan research and educational institute – a think tank – whose mission is to formulate and promote public policies to advance technological innovation and productivity internationally, in Washington, and in the states. Recognizing the vital role of technology in ensuring prosperity, ITIF focuses on innovation, productivity, and digital economy issues. For more information about ITIF, please visit: http://itif.org

About the Brookings Institution Metropolitan Policy Program

Created in 1996, the Metropolitan Policy Program at the Brookings Institution provides decisionmakers with cutting-edge trend research and concrete policy ideas for improving the prosperity of cities and metropolitan areas. Based on the simple premise that the United States is a metropolitan nation, the Metro program works to help metropolitan areas (and thereby the nation) prosper by adapting to rapid economic, demographic, and technological changes. For more information about the Brookings Metro program, please visit: http://brookings.edu/metro/

Endnotes

1. Shellenberger et al, "Fast, Clean, & Cheap," Harvard Law and Policy Review, 2008, vol. 2, no. 1, www.thebreakthrough.org/blog/Fast%20Clean%20Cheap.pdf.

2. Pew Charitable Trusts, "Who's Winning the Clean Energy Race?" March 2010, www.pewtrusts.org/uploadedFiles/wwwpewtrustsorg/Reports/Global_warming/G-20%20Report.pdf.

3. World Economic Forum, "Green Investing: Toward a Clean Energy Infrastructure," January 2009, www.weforum.org/pdf/climate/Green.pdf. Note that this market estimate and the one above both exclude some key low-carbon energy technology sectors such as nuclear power, clean vehicles, and high-speed rail. Full market size for a broader set of clean technologies is undoubtedly larger.

4. For example, the U.S. Environmental Protection Agency (EPA) projects carbon prices under the House-passed American Clean Energy and Security Act (ACESA) would average just over $15 per ton of CO2-equivalent over the first decade of the program (from 2012-2021). Furthermore, the bill's renewable electricity standard would not require the deployment of new renewable technologies beyond business-as-usual projections. See: Rob Atkinson et al, "Rising Tigers, Sleeping Giant," Breakthrough Institute and Information Technology and Innovation Foundation, November 2009, (p. 9, 85), www.thebreakthrough.org/blog/2009/11/rising_tigers_sleeping_giant_o.shtml.

5. For an expansive set of recommendations for how the U.S. government should strengthen clean energy competitiveness, see: Rob Atkinson et al, "Rising Tigers, Sleeping Giant," Breakthrough Institute and Information Technology and Innovation Foundation, November 2009, www.thebreakthrough.org/blog/2009/11/rising_tigers_sleeping_giant_o.shtml.

6. Market analysts project the clean energy market will grow to $600 billion by 2020 (see Word Economic Forum, "Green Investing: Toward a Clean Energy Infrastructure," op. cit. endnote 3), but the sector could reach a much larger scale if full market potential is realized. For example, a recent opportunity estimate for China alone predicted a market opportunity of $500 billion to $1 trillion. See: China Green Tech Initiative, "The China Greentech Report 2009," September 10, 2009, www.china-greentech.com/report.

7. "A Cost-Benefit Analysis of Government Investment in Post-Secondary Education Under the World War II GI Bill," Subcommittee on Education and Health of the Joint Economic Committee, December 14, 1988

8. Rob Atkinson, The Past and Future of America's Economy: Waves of Innovation that Power Cycles of Growth, Northampton, Massachusetts: Edward Elgar, 2005, (p. 272).

9. Greg Tassey, "The Economics of Technology-Based Service Sector," Planning Report 98-2, National Institutes of Standard and Technology, 1998.

10. Rob Atkinson and Scott Andes, "The Atlantic Century: Benchmarking EU and U.S. Innovation and Competitiveness," Information Technology and Innovation Foundation, February 2009, www.itif.org/files/2009-atlantic-century.pdf.

11. Ibid.

12. Atkinson et al, "Rising Tigers, Sleeping Giant," op. cit. endnote 5.

13. Jim Duderstadt et al, "Energy Discovery-Innovation Institutes: A Step toward America's Energy Sustainability." Brookings Institution, 2008, www.brookings.edu/reports/2009/0209_energy_innovation_muro.aspx. See also: Jesse Jenkins, "National Institutes of Energy Needed to Fill Energy R&D Gap," Breakthrough Institute, October 9, 2009, www.thebreakthrough.org/blog/2009/10/national_institutes_of_energy.shtml.

14. For example, U.S. semiconductor firm, Applied Materials, the leading producer of the equipment used to manufacturing solar cells, recently opened the world's largest and most advanced solar energy R&D center in Xi'an, China and sent their Chief Technology Officer there to oversee the project. IBM recently announced a $40 million investment in a new "energy and utility solutions" lab in China that will perform cutting edge work on smart grid and other clean technologies. And GE is now putting their Chinese research centers in the lead to develop new clean tech products like wind turbines and power control electronics. See: Jesse Jenkins, "Clean energy jobs CAN be shipped overseas (and what to do about it)," Breakthrough Institute, April 20, 2010, www.thebreakthrough.org/blog/2010/04/clean_energy_jobs_can_be_shipp_1.shtml.

15. Atkinson et al, "Rising Tigers, Sleeping Giant," op. cit. endnote 5.

16. George Sterzinger and Matt Svrcek, "Wind Turbine Development: Location of Manufacturing Activity," Renewable Energy Policy Project, 2004. The REPP study estimated the potential to create roughly 3,000 manufacturing jobs, in comparison to only 600 jobs in operations and maintenance and 700 temporary installation jobs.

17. For example, the United States lags Japan and China in solar manufacturing capacity, with 30% and 20% of their capacities, respectively. China also has nearly double the wind turbine manufacturing capacity as does the United States. Source: Atkinson et al, "Rising Tigers, Sleeping Giant," op. cit. endnote 5.

18. Rob Atkinson, "8 Ideas for Improving the America COMPETES Act," Information Technology and Innovation Foundation, March 2010, www.itif.org/files/2010-america-competes.pdf.

19. Jeffrey J. Kuenzi, "Stem Education: Background, Federal Policy, and Legislative Action," Congressional Research Service, 2008, www.fas.org/sgp/crs/misc/RL33434.pdf.

20. Science and Engineering Indicators, National Science Foundation, 2008, www.nsf.gov/statistics/seind08/pdfstart.htm.

21. "Current and Potential Green Jobs in the U.S. Economy," U.S. Council of Mayors, 2008, www.usmayors.org/pressreleases/uploads/GreenJobsReport.pdf.

22. FY2010 Budget Proposal for RE-ENERGYSE, Energy Efficiency and Renewable Energy, U.S. Department of Energy, 2009, www.thebreakthrough.org/blog/RE-ENERGYSE_Initiative_DOE_Description.pdf.

23. Office of U.S. Senator Ron Wyden. "Major Opportunities and Challenges to U.S. Exports of Environmental Goods," December 9, 2009, http://wyden.senate.gov/newsroom/120809jw_enviro_goods_report.pdf.

24. Ibid.

25. The America COMPETES Act was largely inspired by a landmark 2007 report from the joint National Academies, "Rising Above the Gathering Storm." See: www.nap.edu/catalog.php?record_id=11463.

26. The Administration requested $115 million in funding for the program in the FY2010 budget, but was rejected by Congressional appropriators.

27. Starting in 1958, NDEA invested $1 billion over four years in loans, scholarships, and graduate fellowships. Source: Jennifer L. Lolly, "The National Defense Education Act, Current STEM Initiative, and the Gifted," Historical Perspectives, (32), vol 2, Spring 2009.

28. National Energy Education Act, Breakthrough Institute, October 2008, www.thebreakthrough.org/blog/NEEA%20Concept%20Proposal.pdf.

29. This estimate is based on funding 40-80 university programs at $0.5 million to $1 million each. The program would be administered by the Department of Energy with grants awarded for up to five years to institutes of higher education on a competitive, merit-reviewed basis based on proposed programs to expand curricula, educational programs, and research opportunities in energy sciences, technology, engineering, mathematics and multidisciplinary energy studies programs; attract and retain specialized faculty; develop new minors, majors, graduate programs, certificates and other courses of study in energy fields; and attract and retain new students for such programs.

30. This interdisciplinary energy studies program could be modeled after the program described in the Department of Energy's RE-ENERGYSE proposal to support interdisciplinary energy curriculum development, equip laboratories, develop faculty lecture series, and encourage energy-focused research by masters students. The professional energy science masters program could also be modeled after the Sloan Foundation's Professional Science Masters initiative, an innovative, new graduate degree program designed to allow students to pursue advanced training in science, while simultaneously developing workplace skills highly valued by employers. See: www.sciencemasters.com

31. DOE and the Department of Education should administer the financial assistance program. At minimum, funding at this level would be sufficient to provide four year scholarships valued at $5,000 per year to 10,000 students annually, but could potentially reach more students with a combination of less direct aid (subsidized loans, loan forgiveness, etc.) or smaller scholarships (e.g. $2,500) per year.

32. Similar programs are already managed by the DOE Office of Science's Office of Workforce Development and the Office of Energy Efficiency and Renewable Energy, which could be applied here to strengthen energy STEM placement opportunities.

33. This would be sufficient to provide $20,000 fellowships for up to three years per student for 1,000 students. The National Academies report, Rising Above the Gathering Storm, calls for the creation of 5,000 new graduate fellowships providing $20,000 per year for tuition and fees. A fellowship at $40,000 per year would bring them more in line with Graduate Research Fellowship Program offered by the National Science Foundation (see: http://www.nsfgrfp.org/). The Association of American Universities also calls for 5,000 new graduate fellowships administered through existing programs as well as the creation of 1,000 new graduate fellowships specifically in energy innovation in their 2006 proposal (see: www.aau.edu/policy/national_defense_education_innovation.aspx). Masters and doctoral fellowships could be provided through DOE's Protecting America's Competitive Edge (PACE) program authorized by America COMPETES (Section 5009), under NSF graduate fellowship programs or new professional masters degree programs in energy related fields, or similar programs.

34. Awards currently authorized under America COMPETES for Department of Energy early career awards for science, engineering, and mathematics researchers (Section 5006) range from $80,000 and $150,000 per year. $50 million annually would be sufficient to grant awards supporting between 333 and 625 post-doc students in any given year. Awards would be granted for up five years for any individual.

35. Deborah Stine, "America COMPETES Act and the FY2010 Budget," Congressional Research Service, June 11, 2009, www.fas.org/sgp/crs/misc/R40519.pdf.

36. In addition to basic energy science, a substantial portion of the DOE Office of Science budget is dedicated to non-energy related research in fields such as particle physics, nuclear science, and advanced computational science. See http://www.energy.gov/about/budget.htm.

37. For more information about ERCs, see: www.nsf.gov/funding/pgm_summ.jsp?pims_id=501026.

38. Examples of needed breakthroughs include expanding the storage capacity of electric batteries through chemistry research, and creating new materials for low-cost solar panels or high temperature nuclear reactors.

39. EFRC awarded grants to 46 applicants in 2009 for a total 5-year commitment of $777 million in awards or $155.4 million annually. See: www.er.doe.gov/bes/EFRC_Award_List.pdf.

40. The EFRC program's first solicitation for applications in late 2008 received approximately 260 applications involving 385 institutions. The total requested budget for all applications over the 5-year project period was approximately $4.9 billion; the annualized request for all applications was approximately $980 million. Assuming even a portion (1/5th) of these applications are worthy of funding and assuming future solicitations receive greater response (as potential applicants become aware of this new program), we approximate that within three to five years, roughly $300 million per year will be necessary to fulfill the budgetary requests of qualified applications.

41. See endnote 6 for explanation.

42. See, for example, Duderstadt et al, "Energy Discovery-Innovation Institutes," op. cit. endnote 13.

43. Congress funded three of eight Hubs in the FY2010, including Hubs on fuels from sunlight, energy efficient buildings and system design, and nuclear modeling and simulation. Energy Secretary Steven Chu has requested funding for one more Hub, focused on batteries and energy storage, in the FY2011 budget.

44. This funding level is consistent with the Administration's original FY2010 request.

45. Rob Atkinson, "Create Jobs by Expanding the R&D Tax Credit," Information Technology and Innovation Foundation, January 26, 2010, www.itif.org/publications/create-jobs-expanding-rd-tax-credit.

46. This was established as section 1351 in the 2005 Energy Policy Act.

47. "The Future of the Hollings Manufacturing Extension Partnership," National Institute of Standards and Technology. December 2008, www.nist.gov/mep/upload/MEP_ExecSummary72dpi.pdf.

48. See Title II, Subtitle D, Sec. 247 of the American Clean Energy and Security Act, HR 2454, as passed and engrossed by the U.S. House of Representatives.

49. A similar proposal, introduced by Senator Brown (D-OH), was included in ACESA (HR 2454). The Investments for Manufacturing Progress and Clean Technology (IMPACT) Act, would authorize the creation of a revolving loan fund valued at $30 billion. See: http://brown.senate.gov/newsroom/press_releases/release/?id=c7c464dd-079a-47f5-911c-b95f5a9282d8.

50. This is similar to a proposal being discussed by Senator Brown (D-OH).

51. These recommended changes to the 48C tax credit criteria are discussed in greater detail in: Rob Atkinson, Testimony on the Importance of Innovation in Clean Energy, Senate Finance Committee, Subcommittee on Energy, Natural Resources and Energy, May 20, 2010, www.itif.org/publications/testimony-importance-innovation-clean-energy.

52. See, for example, Rob Atkinson and Howard Wial, "Boosting Productivity, Innovation, and Growth Through a National Innovation Foundation, Brookings Institution and Information Technology and Innovation Foundation, 2008, www.brookings.edu/reports/2008/04_federal_role_atkinson_wial.aspx.

53. See Karen G. Mills et al, "Clusters and Competitiveness: A New Federal Role for Stimulating Regional Economies," Brookings Institution, 2008, www.brookings.edu/reports/2008/04_competitiveness_mills.aspx. See also: Mark Muro et al, "Why National Policy Should Engage in Support of Regional Cluster Initiatives," Unpublished memo, Brookings Institution, July 2009.

54. Perhaps the most famous such cluster is Silicon Valley, although other notable examples include Detroit's historic leadership in automotive technology, biomedical firms clustered around the Philadelphia and San Francisco Bay areas, the "Research Triangle" region of North Carolina, the "Route 128 Corridor" near Boston, and defense related firms in the Virginia and Washington D.C. area, and many others. In fact, much of America's cutting edge innovation and economic activity occurs within these regional clusters. See: Mills et al, "Clusters and Competitiveness," op. cit. endnote 53.

55. See: Mills et al, "Clusters and Competitiveness," op. cit. endnote 53.

56. The program would provide regional planning and matching grants focused on leveraging regions' competitive strengths to boost job creation and economic growth (see pages 2, 41, 46 of the Department of Commerce-Budget in-Brief, www.osec.doc.gov/bmi/budget/FY2011BIB.html.). For background on this and other cluster-oriented FY2011 budget initiatives see Mark Muro, "Budget 2011: Industry Clusters as a Paradigm for Job Growth," The Avenue, a blog of the New Republic, February 2, 2010, www.tnr.com/blog/the-avenue/budget-2011-industry-clusters-paradigm-job-growth.

57. A clusters strategy can also increase the effectiveness of DOE R&D programs and accelerating the pace of innovation by providing DOE programs with a greater understanding of market challenges for emerging clean energy technologies and opportunities for technology improvement that feed back into and better inform the research process.

58. Department of Energy, Energy Efficient Building Systems Regional Cluster Initiative, www.energy.gov/hubs/eric.htm.

59. See: Duderstadt et al, "Energy Discovery-Innovation Institutes," op. cit. endnote 13; and Peter Rothstein, "Building Clean Energy Innovation Consortia and Clusters," New England Clean Energy Council, 2009, www.energyinnovationconsortia.org/about/links-and-resources/.

60. Model language describing such consortia can be found in Section 171 of the American Clean Energy and Security Act, HR 2454.

61. Both Breakthrough Institute and Brookings Institution have proposed new institutional paradigms to support translational clean energy R&D and spur competitive regional economic clusters, and we view this pilot initiative as an important first step in moving toward the implementation of this shared larger vision. See: Duderstadt et al, "Energy Discovery-Innovation Institutes" op. cit. endnote 13; and Josh Freed et al, "Jumpstarting a Clean Energy Revolution with a National Institutes of Energy," September 2009, www.thebreakthrough.org/blog/2010/04/jumpstarting_a_clean_energy_re_1.shtml.