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Hubs of Transformation: Leveraging the Great Lakes Research Complex for Energy Sector Innovation

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I. Introduction

No U.S. region more epitomizes the need to transform the national economy to a lower carbon pathway than the Great Lakes region. Energy intensity and carbon intensity—primer drivers of the nation's energy challenges—are hallmarks of the Great Lakes' industrial concentration in manufacturing, agriculture, and transportation. Transforming these industries in this region to be more energy efficient and less fossil fuel reliant is a critical a part of improving U.S. energy security, sustainability, and economic competitiveness.

No U.S. region possesses a richer array of innovation assets to drive the necessary transformation. Anchored by renowned universities and industry titans, the Great Lakes region is a research and development (R&D) powerhouse. The region's world-class network of universities more than hold its own in producing top-flight science and engineering talent, performing competitive R&D, and committing to technology commercialization.[1] And, the formidable industrial base of the Great Lakes provides, even during restructuring, a large-scale private sector platform for R&D, new product creation, and skilled worker training. The region has been, is, and can continue to be a heavyweight in the competitive, global marketplace.

Might these facts, this challenge and these assets, be brought together in a transformative intervention in the Great Lakes region?

This brief contends that they can be, and proposes that throughout the Great Lakes, the federal government launch a network of federally-funded, regionally-oriented, commercialization-driven, widely collaborative energy innovation hubs to lead a transformation of the region's transportation industry based upon sustainable energy technologies. In the spirit of the earlier land-grant paradigm, this network involve the region's research universities and involve strong participation by industry, entrepreneurs and investors, and state and local government. Each hub would have a different theme, but they would all conduct the translational research necessary to move fundamental scientific discoveries to the commercialization and deployment of new energy technologies. The unprecedented scale of university-industry-government partnerships that would emerge from this Great Lakes network of hubs would be a powerful move toward solving the nation's energy crises, while also re-invigorating the regional economy through innovation.

II. The Great Lakes Region Stages all of America's Key Energy Challenges

The region, like the nation, faces a huge problem in moving away from fossil fuels. As Americans across the country build more, drive more, and produce more, they demand more energy. And with alternative energy sources, like nuclear, solar, wind, and biomass power, constituting mere fractions of overall energy consumption, the U.S. suffers a continuing national dependency on fossil fuels.[2] The industrial sector, which makes up the largest share (over a third) of all U.S. energy consumption, is also the most reliant on fossil fuels.[3] It is a prime target for much needed energy innovation, with the Great Lakes being the nation's epicenter for "greening" U.S. industry to boost national economic competitiveness, tackle climate change, and improve energy security. Heavy in the manufacturing of metals, chemicals, glass, automobiles, and petroleum refining, the Great Lakes states accounts for over 30 percent of all U.S. industrial carbon emissions.[4]

Yet, despite the scale of the problem of turning away from fossil fuels, developments in new energy technologies across the country are greatly lacking. One reason for this dire need is that the research intensity of the energy sector is woefully inadequate. The 0.3 percent of output that the energy sector annually devotes to R&D is hardly sufficient for driving innovation in the industry, and, indeed, lags far behind the 2.0 percent committed by the health care sector, the 2.4 percent by agriculture, and the 10 percent by information technology and pharmaceutical industries.[5]

Indeed, multiple barriers prevent sufficient private investment in energy innovation. First, energy prices have generally remained too low to incent companies to commit to clean and efficient energy technologies and processes over the long haul. Second, the reality of spillover benefits means that individual firms can rarely capture all of the benefits of their innovative activity and so will tend to under-invest and focus on short-term, low-risk research and product development. Third, uncertainty and lack of information about the market and policy conditions relevant to energy consumption and production, and the possible benefits of new energy technologies and processes may further delay innovation. Fourth, the benefits of regional industry clustering, which include facilitating technology innovation, have yet to be fully realized for next-generation energy enterprises, which are often connected to secure laboratory settings. Additionally, state and local governments, burdened with budgetary pressures and many of the same limitations listed above, are unable to meet outstanding gaps in energy innovation investment.

III. Current federal policy remains flawed and unequal to the task of remaking the U.S. energy innovation system

In the face of the compelling need for energy innovation and the various market failures preventing sufficient investment, the federal government has a critical role to play in accelerating the development of new energy technologies. Unfortunately, it has long failed to adapt to 21st century energy needs and realities and has only recently begun to change.

1. The scale of federal energy research funding is insufficient

The current federal appropriation of $5.2 billion a year for non-defense energy-related R&D is well below the $8 billion (in real 2008 dollars) recorded in 1980, and is in fact only about one-quarter of the

1980 investment level when measured as share of national GDP. Today's federal commitment is far too small to ensure the development of a sustainable energy economy in America. If the federal government were to prioritize next-generation energy as much as advances in health care, national defense, or space exploration, the level of investment would be much larger in the neighborhood of $20 to $30 billion a year.[6]

2. The character and format of federal energy R&D remain inadequate

The DOE national laboratories—which anchor the nation's present energy research efforts—are far too insular, fragmented in their activities, and removed from market, legal, and social realities to successfully develop and deploy cost-competitive new energy technologies that are easily adopted on a large-scale.[7] . Most notably, DOE activities focus largely on discrete fuel sources (e.g., coal, oil, gas, nuclear) rather than the fully integrated approaches needed to realize affordable, reliable, sustainable energy. Such a siloed set-up is simply not well suited to tackling the complexity of the nation's real-world energy challenges, like moving the Great Lakes transportation industry toward a clean energy infrastructure. This is a transition requires a multi-pronged, full-systems approach that depends not only upon R&D in technologies such as alternative propulsion technologies (biofuels, hydrogen, electrification) and vehicle design (powertrains, robust materials, advanced computer controls), but also engages far broader technology development, including primary energy sources, electricity generation and transmission, and energy efficient applications that in the end will determine the economic viability of this important industry.

3. Federal programming fails to fully realize regional potential

The weakness of the current federal approach in boosting energy innovation means that, in regions around the country, assets that could serve to accelerate advances in new energy technologies remain untapped, underutilized, or poorly leveraged or connected with one another. In the Great Lakes, for example, current federal policy—to the detriment of the national interest—does little to tie together the billions of dollars of science and engineering R&D conducted annually by the region's academic institutions; all available private and public sector financing for clean energy; natural resources in wind and biomass; and robust, pre-existing industrial platforms for research, next-generation manufacturing, and technology adoption and deployment.

4. Recent federal efforts do ramp up and revamp federal energy research, but still fall short

To begin with, the American Recovery and Reinvestment Act (ARRA) provided nearly $13 billion in total for DOE investments in advanced energy technology research and scientific innovation.[8] Like other regions around the country, the Great Lakes benefits from this welcome funding boost for energy innovation activities. As part of DOE Recovery Act funding, the Great Lakes states are slated to receive 42 percent of all award funds announced to date from the fossil energy R&D program and 39 percent from the Office of Science, a basic research agency widely regarded as critical for the nation's energy future.[9]

But ARRA was a one-time injection that cannot be counted on sustain federal energy R&D at the necessary level into the future. Indeed, even though the FY2011 budget request from the administration continues to prioritize energy innovation investments and calls for boosting the budget of the DOE

Office of Science by 4.6% to some $5.1 billion, the total federal commitment to advanced and applied clean energy research and technology deployment remains far below the $15 billion target called for by many experts.[10]

Additionally, two relatively recent DOE programs, Advanced Research Projects Agency-Energy (ARPA-E) and Energy Frontier Research Centers (EFRCs) do well to support dimensions of R&D currently stymied by DOE's infrastructure: high-risk/high-reward breakthroughs and small group, cross-sector collaborations, respectively. Again, the Great Lakes states have successfully tapped into these new opportunities, currently accounting for roughly 44 percent and 50 percent of ARPA-E and EFRC announced funding, respectively, for such projects as algae harvesting, advanced high-capacity batteries, and solar energy conversion. Yet, with the former program singularly focused on individual signature projects and the latter on basic research, neither alone has the scope to fully engage all regional innovation assets to accelerate the nation's transition to a clean, sustainable energy infrastructure.[11]

And then there are the recently authorized DOE Energy Innovation Hubs for FY2010.[12] Although in many respects similar to the type of energy hubs proposed in this policy brief, the DOE program is, at its outset, designed for only three, relatively small, basic and applied research centers with top-down technology assignments, rather than broader interdisciplinary collaborations that operate in a bottom-up fashion and explicitly connect to regional industry clusters.[13]

IV. Federal policy should adopt a new paradigm for energy research and innovation

The federal government should pursue a major systematic effort to accelerate clean energy innovation by strategically building out a nationwide system of regionally-based energy research centers, organized in a hub-spoke structure to link fundamental scientific discoveries with technological innovation.[14] Originally introduced in the Brookings policy proposal, "Energy Discovery-Innovation Institutes: A Step Toward America's Energy Sustainability," these *energy discovery-innovation institutes*–now renamed *energy innovation hubs*–would conduct the translational R&D necessary to realize the full potential of new sustainable energy technologies. Involving research universities, national laboratories, and private industry, the proposed hubs would address national sustainable energy priorities, while also being firmly rooted in regional economies, both transferring clean energy technologies to local industry and stimulating local economic growth.

The Great Lakes is ripe for a federal attack that "floods the zone" with an array of these high-powered, market-focused, tech transfer-driven energy innovation hubs, strategically situated across the region to reach critical mass through their number, size, variety, orientation to regional industry clusters, and networking. This region offers many energy innovation-related strengths that make it the appropriate place for the federal government to launch a massive new clean energy innovation push:

- *Recognized leadership in R&D.* The Great Lakes accounts for 33 percent of all academic and 30 of all industry R&D performed in the U.S.
- *Strength and specialization in energy, science and engineering.* DOE sent 26 percent of its federal R&D obligations to the Great Lakes states in FY2006 and is the second largest federal funder of industrial R&D in the region. Similarly, the National Science Foundation

(NSF) sent 30 percent of its federal R&D obligations there and is the second largest federal funder of the region's academic R&D.[15]

- *Industry potential relevant to clean energy.* Given overlap some of the existing technologies already produced in the Great Lakes, the industry there has the potential to excel in the research and manufacture of the sophisticated components required for clean energy, such as those in precision wind turbines and complex photovoltaics.[16]
- *Breadth in energy innovation endeavors and resources.* In addition to universities and industry, the Great Lakes network of energy hubs could draw on the existing R&D in energy storage systems and fuel and engine efficiency taking place at Argonne National Laboratory (ANL) and the work on bioenergy feedstocks, processing technologies, and fuels occurring at the DOE-funded Great Lakes BioEnergy Research Center (GLBRC).[17]
- *Regional culture of collaboration.* The universities of the Great Lakes have a strong history of collaboration both among themselves and with industry given their origins in federal land grant compact of market and social engagement. GLBRC, one of the nation's three competitively awarded DOE Bioenergy Centers, is evidence of the region's ability to purposefully align academia, industry, and government around one mission.

The proposed Great Lakes network of energy innovation hubs is a way to marshal varied and dispersed regional capabilities and resources to address the nation's present energy challenges. As envisioned here, the hubs network would:

1. Organize individual hubs around themes

The different energy innovation hubs of the Great Lakes would vary in mission and scope according to local R&D strengths and capacity. For example, a major hub in southeastern Michigan might draw in the University of Michigan, and Michigan State and University of Wisconsin system together with industry leaders, Ford, GM, and Dow to address the development of sustainable transportation technologies. In the Chicago region, a major hub might involve Northwestern and Purdue Universities as well as the University of Chicago and Indiana University in conjunction with DOE's Argonne National Lab and the firms of Excelon and Boeing to focus on sustainable electricity generation and distribution. Still another large hub in the Columbus area may partner Ohio State University and Battelle could address technologies for energy efficiency. Additional hubs would be located according to other university and industry capabilities dispersed throughout the region

2. Foster multidisciplinary and collaborative research partnerships

Compared to the existing regional R&D infrastructure, the hubs would seek to better align the nonlinear flow of knowledge and activity among scientific discovery, technological innovation, entrepreneurial business development, and economic, legal, social, and political imperatives. They would tap the resources and capabilities of multiple players, including companies, entrepreneurs, commercialization specialists, and investors as well as government agencies (federal, state, and local) and research universities. They would also purposefully engage in both science and engineering and non-science disciplines. In a sense, each hub in the netowrk would create an "R&D commons," where strong, symbiotic partnerships could be created and sustained among partners with different missions and cultures.

3. Serve as a distributed "hub-spoke" network linking together campus-based, industry-based, and federal laboratory-based scientists and engineers

A distributed research network, in which each energy innovation hub acts as the "hub" and other basic R&D programs, centers, and facilities of related institutions serve as "spokes", would couple fundamental scientific research and discovery with translational research, technology development, and commercial deployment. The hub-and-spoke network architecture would also enable the "spokes" to interact and collaborate among themselves through exchanges of participants, regularly scheduled meetings, and advanced information and communications technology.

On this last point, the energy innovation hubs network would be undergirded by powerful cyberinfrastructure and overlaid by a network of virtual organizations involving scientists, engineers, industrial management, and federal participants. This way the network could provide a powerful test-bed for new types of research organizations able to reduce unnecessary duplication of costly facilities and cumbersome management bureaucracy. Such coordination would also allow separate Great Lakes hubs, focused on different themes, to remain connected and coordinated in pursuit of larger national goals.

4. Develop and rapidly deploy highly innovation technologies to the marketplace

Commercialization would be the crucial objective of the Great Lakes network of energy innovation hubs, which would in every instance work closely with industry, entrepreneurs, and the investment community to execute a program of "use-inspired" research designed to accelerate the conversion of scientific breakthroughs into commercial deployment. Rather than aim for revenue maximization, technology transfer in the hubs would be structured to maximize the volume, speed, and positive societal impact of commercialization. As much as possible, the hubs would work out in advance patenting and licensing rights and other intellectual property issues to facilitate fast and appropriate pathways to market. The success of the hub would be measured by the results and rewarded accordingly.

5. Build the knowledge base necessary to address the nation's energy challenges

The hubs would also lead the development of educational programs and distributed educational networks that could produce new knowledge for innovation and educate future scientists, engineers, innovators, and entrepreneurs of the future, as well as learners of all ages on the challenge of changing the U.S. energy paradigm. This sort of public education would a component of the hubs' fundamental mission and their scientists and engineers would collaborate with K-12 schools, community colleges, regional universities, and workplace training initiatives on best educational practices.

6. Stimulate regional economic development

Like academic medical centers and agricultural experiment stations—both of which combine research, education, and professional practice—energy innovation hubs could also successfully generate jobs and stimulate regional economic activity through the nearby location of start-up firms, private research organizations, suppliers, and other complementary groups and businesses. By better aligning within metropolitan regions, the multiple, often disparate, energy-related activities of federal and state

government, academia, large and small business, and the investment community, the hubs would greatly facilitate cross-sector knowledge spillovers, innovation exchange, profligate technology transfer to support clusters of start-up firms, research organizations, suppliers, and other players—the true seedbed of greater regional innovation and productivity. And, by explicitly focusing on the regional industry clusters characterizing their home regions, hubs would aim to ensure that regional R&D capabilities respond to local conditions so that they produce new technologies that could be readily deployed in the surrounding marketplace.

7. Complement efforts at DOE's national laboratories but be organizationally and managerially separate

The national laboratories have the unique capacity for large-scale, infrastructure-intensive projects that require substantial technical and management talent. The hubs should not duplicate this expertise and infrastructure, but instead utilize a different research and translation paradigm to collaborate with industry, companies, investors, and governments to speed the movement of breakthroughs into widespread implementation.

8. Utilize a tiered organization and management structure

Each hub would have a strong external advisory board representing the participating partners, including government, industry, nonprofits, entrepreneurs, and investors. In some cases, partners might play direct management roles with executive authority. The precise organizational and management structure for hubs is not prescribed here, as it should be a component of the evaluation process to award the hub funding. This way the proposal process encourages competition, creativity, and innovation and ensures that the hubs have maximum flexibility to achieve meaningful advances in energy research and technology development.

9. Adopt a competitive award process with specific selection criteria

A competitive award process would designate hubs for federal support and inclusion in the Great Lakes network. Proposals would be evaluated by an interagency panel and subject to rigorous peer review according to criteria primarily involving scientific merit and capability. Additionally, other selection criteria would consider the commitments of various partners participating in the hub (e.g., universities, industry, labs, government, and private investors); strength of the hub management plan; strategies for commercialization, including approaches to tech transfer and intellectual property issues; plans for connecting the proposed hub to the regional network.

10. Receive as much federal funding as major DOE labs

Given the massive responsibilities of the proposed Great Lakes energy innovation hubs, total federal funding for the whole network should be comparable to that of comprehensive DOE labs, such as Los Alamos, Lawrence Livermore, Oak Ridge, Idaho, and Sandia—each of which have FY2010 budgets between $1 billion and $2 billion.[18] Additional investment in the Great Lakes hubs network would come from state governments, business and industry, and other investors

VI. Conclusion

America's national energy infrastructure, based primarily upon fossil fuels, must be replaced with new technologies before economic prosperity, national security, and natural environment are severely damaged. This calls for significant technological innovation. The Great Lakes are emblematic of both the national challenge of transforming a heavily energy and carbon intensive economy and the national opportunity of marshalling many existing innovation assets to catalyze breakthroughs, development, and market adoption of new technologies.

Through the proposed Great Lakes network of energy innovation hubs, a resilient nation could increase federal R&D investment in the region in a way that better integrates scientific research, technology development and commercialization, and the production of human resources across a broad range of scientific, technological, economic, behavioral, and public policy. By catalyzing a new partnership of research universities, federal laboratories, business and industry, entrepreneurs and investors, and federal, state, and local government, this model could stimulate transformation of the energy-intensive manufacturing, agriculture, and transportation activities anchoring the Great Lakes' economy, while also inventing a sustainable national energy infrastructure for the 21st century.

More generally, this policy intervention would represent a major federal contribution to restoring economic strength and prosperity to a region that served earlier generations as the economic engine of the global economy and the arsenal of democracy!

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[1] Frank E. Samuel. "Turning up the Heat: How Venture Capital Can Help Fuel the Economic Transformation of the Great Lakes Region" (Washington: Brookings, 2010).

[2] http://tonto.eia.doe.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=44&pid=44&aid=2 ; http://www.eia.doe.gov/oiaf/aeo/overview.html

[3] http://www.eia.doe.gov/emeu/aer/consump.html

[4] http://tonto.eia.doe.gov/state/index.cfm ; Project Vulcan

[5] James Duderstadt and others. "Energy Discovery Innovation Institutes: A Step Toward America's Energy Sustainability" (Washington: Brookings, 2009).

[6] Duderstadt, "Energy Discovery Innovation Institutes."

[7] Duderstadt, "Energy Discovery Innovation Institutes."

[8] The Breakthrough Institute analysis of federal energy budgets.

[9] DOE Recovery Act Project Breakdown by State as of November 2009 available at http://www.energy.gov/recovery/7008.htm

[10] Budget information available at http://www.whitehouse.gov/omb/factsheet_department_energy/. For R&D targets, see Mark Muro and Sarah Rahman, "$15 Billion: The New Energy Target" in The Avenue a blog of *The New Republic,* November 2, 2009, available at www.tnr.com/blog/the-avenue/15-billion-the-new-energy-target.

[11] DOE Recovery Act Project Breakdown by State as of November 2009 available at http://www.energy.gov/recovery/7008.htm. ARRA provided $400 million for ARPA-E grants; see http://arpa-e.energy.gov/. EFRC's are funded at $500 million over 5 years; see www.er.doe.gov/bes/efrc.html

[12] Funded at $22 million each, three hubs are expected to launch over the next year in the focus areas of solar energy, building energy efficiency, and nuclear modeling and simulation. For more information DOE Energy Innovation Hubs, see www.energy.gov/hubs/

[13] http://www.energy.gov/hubs/qanda.htm

[14] Duderstadt, "Energy Discovery Innovation Institutes."

[15] NSF Science and Engineering State Profiles: 2006-2008 available at http://www.nsf.gov/statistics/nsf10302/

[16] John Austin, Elaine Dezenski, and Britany Afffolter-Caine. "The Vital Connection: Reclaiming the Great Lakes Economic Leadership in the Bi-National US-Canadian Region" (Washington: Brookings, 2008).

[17] http://www.anl.gov/Administration/index.htmll http://www.greatlakesbioenergy.org/mission/

[18] DOE FY2010 Budget Request to Congress. Available at www.energy.gov/about/budget.htm