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

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America needs to transform its energy system and the Great Lakes region possesses many of the needed innovation assets. For that reason, the federal government should leverage a troubled region's research and engineering strengths in support of the national interest through the launch of a region-wide network of collaborative, high-intensity energy research and innovation centers.

Such an initiative would respond as much to America's need to transform its energy system as to the need to revitalize the industrial Midwest.

Currently, U.S. energy innovation efforts remain insufficient to ensure the development and deployment of clean energy technologies and processes. On the one hand, such deployment is impeded by multiple market problems—ranging from relatively low energy prices and information and regulatory uncertainties to the reality of innovation spillovers—that lead private firms to under-invest and focus on short-term, low-risk research and product development. On the other, federal energy efforts—let alone state and local ones--remain at once too small and too poorly organized to deliver the needed breakthroughs, with too much of the nation's exploration conducted in "siloed" labs that remain too far removed from the marketplace and its need for translational, "use inspired" research.

And so the federal government should systematically accelerate national clean energy innovation by launching in the Great Lakes region a series of "themed" research and commercialization centers strategically situated to draw on the Midwest's rich complex of strong public universities, national and corporate research labs, top-flight science and engineering talent. Organized around existing capacities in a hub-spoke structure designed to link fundamental science with innovation and commercialization, these research centers would engage universities, industries, and labs to work on individual issues to rapidly deploy new technologies to the marketplace. Along the way they might well begin to transform a struggling region's ailing metropolitan economies. Roughly six compelling innovation centers could reasonably by organized across the Great Lakes states with total annual funding between $1 and $2 billion.

I. Introduction

America needs to transform its energy system in order to create a more competitive "next economy" that is at once export-oriented, lower-carbon, and innovation-driven.

The Great Lakes region possesses what may be the nation's richest complex of innovation assets including research universities, national and corporate research labs, and top-flight science and engineering talent.

Is there an exchange to be done? Might these facts—both the nation's needs and a struggling region's assets—be brought together in a transformative intervention in the Great Lakes region?

This brief contends that yes, there *is* a partnership to be forged, and so proposes that the federal government launch in the auto industry-dependent communities of the Great Lakes a distributed network of federally-funded, commercialization-oriented energy research and innovation centers to lead a transformation of the Great Lakes area's—and the nation's—industries and regional economies based upon sustainable energy technologies. These regional centers would combine aspects of the "discovery-innovation institutes" proposed by the National Academy of Engineering and the Brookings Institution, the "energy innovation hubs" created by the Department of Energy, and the agricultural experiment station/cooperative extension model of the land grant universities to have significant impact both on regional economies and national priorities.

In the spirit of the earlier land-grant university paradigm, this network would involve the region's research universities and national labs and engage strong participation by industry, entrepreneurs, and investors as well as state and local government. In this vein, each center would have a different theme, though all would conduct the intense, focused translational research necessary to move fundamental scientific discoveries to the commercialization and deployment of new energy technologies.

As to the impact, it could be transformational. If built out, the unprecedented scale of the university-industry-government partnerships that would emerge from this Great Lakes network of regional research and innovation centers would represent a powerful force for solving the nation's energy crises while also re-invigorating a flagging the regional economy through innovation. At a minimum, populating auto country with an array of breakthrough-seeking, high-intensity research centers would stage a useful experiment in linking national leadership and local capacities to lead the nation and a region toward a more prosperous future.

II. The Great Lakes Region Epitomizes America's Industrial and Energy System Predicaments and Possibilities

The Great Lakes region lies at the center of the nation's industrial and energy system trials and possibilities.

No region has suffered more from the struggles of America's manufacturing sectors and faltering auto

industry, as indicates a new paper from the Metropolitan Policy Program at Brookings entitled "The Next Economy: Rebuilding Auto Communities and Older Industrial Metros in the Great Lakes Region."

Likewise, and relatedly, the region lies at Ground Zero of the nation's need to "green" U.S. industry to boost national economic competitiveness, tackle climate change, and improve energy security. Heavy in the manufacturing of metals, chemicals, glass, and automobiles as well as petroleum refining, the Great Lakes states account for nearly one-third of all U.S. industrial carbon emissions.

And yet, for all that, the Great Lakes region possesses significant assets and capacities necessary to the nation and promising for its own renewal as the "next economy" comes into view. Engines and laboratories of the American economy of the 20th century, the manufacturing communities of the Midwest have the strong educational and medical institutions, advanced manufacturing prowess, skills base, and other assets that will be essential to helping the nation move toward, and successfully compete in, the export-oriented, lower-carbon, innovation-fueled economy of tomorrow.

Most notably, the Great Lakes region offers the nation an impressive array of the innovation-related strengths in the energy field that will be necessary to generate the technological breakthroughs that will be necessary to decarbonize the nation's economy in the coming decades. Among many others these capacities and assets include:

- *Recognized leadership in R&D.* The Great Lakes accounts for 33 percent of all academic and 30 percent of all industry R&D performed in the U.S.
- *Strength and specialization in energy, science and engineering.* The Department of Energy (DOE) sent 26 percent of its federal R&D obligations to the Great Lakes states in FY 2006 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 R&D obligations there and is the second largest federal funder of the region's academic R&D
- *Existing clean energy research investments and assets.* In biofuels, the University of Illinois is key research partner in the BP-funded, $500 million Energy Biosciences Institute which aims to prototype new plants for alternative fuel sources. In solar pursuits, Toledo already boosts a growing regional industry cluster; Dow Corning's facilities in Michigan produce leading silicon and silicone-based technology innovation; and the Solar Energy Laboratory at the University of Wisconsin-Madison, the oldest of its kind in the world, boast significant proficiency in developing practical uses for solar energy. In nuclear, finally, the region is home to the largest U.S. nuclear utility (Exelon), the nation's largest concentration of nuclear plants, and some of the country's leading university programs in nuclear engineering
- *Industry potential relevant to clean energy.* Given their existing technological specializations, Midwestern industries have the potential to excel in the research and manufacture of sophisticated components required for clean energy, such as those in advanced nuclear technologies, precision wind turbines, and complex photovoltaics
- *Breadth in energy innovation endeavors and resources.* In addition to universities and industry, the Great Lakes possesses numerous research specializations of great relevance to national energy challenges, including work on energy storage systems and fuel and engine efficiency taking place at Argonne National Laboratory (ANL); research in high energy

physics at the Fermi National Accelerator Laboratory; and the work on bioenergy feedstocks, processing technologies, and fuels occurring at the DOE-funded Great Lakes BioEnergy Research Center (GLBRC)

- *Regional culture of collaboration.* Finally, the universities of the Great Lakes have a strong history of collaboration both among themselves and with industry given their origins in the federal land grant compact of market and social engagement. GLBRC--one of the nation's three competitively awarded DOE Bioenergy Centers--epitomizes the region's ability to purposefully align academia, industry, and government around one mission Another example is the NSF-supported Blue Waters Project, a partnership between IBM and the universities and research institutions in the Great Lakes Consortium for Petascale Computation to build the world's fastest computer for scientific work—a critical tool for advancing smart energy grids and transportation systems.

In short, the Great Lakes states and metropolitan areas—economically troubled and carbon-reliant as they are—nevertheless hold out capabilities that could contribute to their own transformation and that of the nation…if the right policies and investments are put in place.

III. America Needs to Remake Its Energy System but Lacks the Federal Policy Framework Needed to Do It

America as a whole, meanwhile, needs to transform its energy system. Massive sustainability and security challenges plague the nation's energy production and delivery system. Transformational innovation and commercialization will be required to address these challenges and accelerate the process of reducing the economy's carbon intensity.

And yet, a welter of market problems is currently impeding decarbonization and limiting the innovation needed to achieve it.

First, energy prices have generally remained too low to provide incentives for companies to commit to clean and efficient energy technologies and processes over the long haul. Second, many of the benefits of long-range innovative activity accrue to parties other than those who make investments so individual firms will tend to under-invest and focus on short-term, low-risk research and product development. Third, uncertainty and lack of information about relevant market and policy conditions and the potential benefits of new energy technologies and processes may be further delaying 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 isolated in secure laboratory settings. And then, finally, state and local governments--burdened with budgetary pressures--are not likely to be able to fill outstanding gaps in energy innovation investment any time soon.

As a result, the research intensity—and so the innovation intensity--of the energy sector remains woefully insufficient. Currently, for example, the energy sector devotes no more than 0.3 percent of its revenues to R&D. Such a figure lags far behind the 2.0 percent of sales committed to federal and large industrial R&D by the health care sector, the 2.4 percent by agriculture, and the 10 percent by information technology and pharmaceutical industries.

As to the national government's efforts to respond to the nation's energy research shortfalls, those

remain equally inadequate. Clearly, the federal government has a critical role to play in accelerating the development of new energy technologies given the compelling need for decarbonization of the U.S. economy and the various market failures impeding it. Unfortunately, current efforts fall short of adapting to and meeting 21st century energy needs and realities. Three major problems loom:

1. The scale of federal energy research funding is insufficient

To begin with, the current federal appropriation of around $3 billion a year for non-defense energy-related R&D simply remains too small. Such a figure remain well below the $8 billion (in real 2008 dollars) recorded in 1980, and in fact represents less than a quarter of the 1980 investment level when measured as share of national GDP. 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.

Nor do the nation's most recent new efforts to catalyze energy innovation appear sufficient to fill the gap. To be sure, the American Recovery and Reinvestment Act (ARRA) provided nearly $13 billion for DOE investments in advanced technology research and innovation—out of which Great Lakes states are slated to receive some 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. However, ARRA was a one-time injection that cannot be counted on sustain federal energy R&D at the necessary level into the future.

Relatedly, the region has done well in tapping into two other relatively recent DOE programs: the Advanced Research Projects Agency–Energy (ARPA-E) and Energy Frontier Research Centers (EFRCs). Currently, Great Lakes states account for 44 and 50 percent of ARPA-E and EFRC announced funding, for work on 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 initiative alone has the scope to fully engage all regional innovation assets to accelerate the nation's transition to a clean, sustainable energy infrastructure.

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

Beyond their scale, though, the character of U.S. energy innovation activities also remains inadequate. In this respect, the DOE national laboratories—which anchor the nation's present energy research efforts—remain poorly utilized resources. With so many of their activities kept isolated from the private sector and fragmented, the labs are, by in large, too removed from market, legal, and social realities to successfully develop and deploy cost-competitive, multi-disciplinary new energy technologies that are easily adopted on a large-scale.

Most notably, DOE activities continue to be focused largely on discrete fuel sources (e.g., coal, oil, gas, nuclear) rather than the fully integrated end-use approaches needed to realize affordable, reliable, sustainable energy. Siloed approaches simply do not work well when it comes to tackling the complexity of the nation's real-world energy challenges. A perfect example of a complicated energy problem requiring an integrated end-use approach is transportation. Moving the nation's transportation industry toward a clean energy infrastructure is a transition that is going to 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 (power trains, robust materials, advanced computer controls) but also on far broader technology development, including in primary energy sources, electricity generation and transmission, and energy efficient applications that in the end will determine the economic viability of this important industry. Siloed research won't work; new research and commercialization paradigms are imperative.

3. Federal programming fails to fully realize regional potential

Related to the structural problems of U.S. energy innovation efforts, finally, is a failure to fully tap or leverage critical preexisting assets within regions that could serve to accelerate technology development and deployment. 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 of the available private- and public-sector clean energy activities and financing; abundant natural resources in wind and biomass; and the region's wealth of robust, pre-existing industrial platforms for research, next-generation manufacturing, and technology adoption and deployment. In this region and elsewhere, federal policy has yet to play a substantial role in connecting researchers at different organizations, breaking down stovepipes between research and industry, bridging the commercialization "valley of death," and in establishing mechanisms that incent and reward quickly and smoothly bringing federally-sponsored R&D to the marketplace.

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In sum, America needs to remake its energy system but lacks the federal innovation investments, institutions, and policy frameworks needed to do it.

IV. Federal Policy Should Test a New Paradigm for Region-Based Energy Research and Innovation

And so the federal government should systematically accelerate national clean energy innovation by launching a series of regionally-based Great Lakes energy research and innovation centers organized in a hub-spoke structure to link fundamental scientific discoveries with technological innovation and commercialization.

Originally introduced in the Brookings policy proposal, "Energy Discovery-Innovation Institutes: A Step Toward America's Energy Sustainability" and called energy discovery-innovation institutes (or e-DIIS), a nationwide network of these *regional centers* would join-up universities, labs, and industry to conduct translational energy R&D that at once addresses national sustainability priorities, while also stimulating local regional economies.

In the Great Lakes, specifically, a federal attack to "flood the zone" with a series of roughly six of these high-powered, market-focused energy centers could strategically situate institutes across the region so they reach critical mass through their number, size, variety, linkages, and orientation to the pre-existing work of the regional research complex and regional industry clusters.

As envisioned here, the Great Lakes network of energy research centers would do the following:

- ***Organize individual centers around themes largely determined by the private market.*** According to local industry research priorities, university capabilities, and the market and commercialization dynamics of various technologies, each Great Lakes research and innovation center would undertake a different focus, such as renewable energy technologies, biofuels, transportation energy, carbon-free electrical power generation and distribution, and energy efficiency

- ***Foster multidisciplinary and collaborative research partnerships***. The regional centers or institutes would better align the nonlinear flow of knowledge and activity across science and non-science disciplines and among companies, entrepreneurs, commercialization specialists, and investors as well as government agencies (federal, state, and local) and research universities. For example, a southeastern Michigan collaboration between University of Michigan, Michigan State, University of Wisconsin and Ford, GM, and Dow could address the development of sustainable transportation technologies. A Chicago partnership between Northwestern and Purdue Universities, the University of Chicago, the University of Illinois, Argonne National Lab and Exelon and Boeing could focus on sustainable electricity generation and distribution. A Columbus group including Ohio State University and Battelle Memorial Institute could address technologies for energy efficiency technologies. In these and other examples, regional industry representatives would be involved from the earliest stages to define the needs that research should address so that technology advances are relevant and any ensuing commercialization process is as successful as possible

- ***Serve as a distributed "hub-spoke" network linking together campus-based, industry-based, and federal laboratory-based scientists and engineers*** The central "hubs" would interact with other R&D programs, centers, and facilities (the "spokes") through exchanges of participants, regularly scheduled meetings, and advanced information and communications technology to limit unnecessary duplication of efforts and cumbersome management bureaucracy and enhance the coordinated pursuit of larger national goals

- ***Develop and rapidly deploy highly innovation technologies to the market.*** Rather than aim for revenue maximization through technology transfer,the regional energy centers would be structured to maximize the volume, speed, and positive societal impact of commercialization. As much as possible, the centers would work out in advance patenting and licensing rights and other intellectual property issues to facilitate fast and appropriate pathways to market. For example, an individual center, might choose to create a standardized template for commercializing lab innovations

- ***Stimulate regional economic development***. Like academic medical centers and agricultural experiment stations—both of which combine research, education, and professional practice—these energy centers could facilitate cross-sector knowledge spillovers, innovation exchange, and profligate technology transfer to support clusters of start-up firms, private research organizations, suppliers, and other complementary groups and businesses—the true regional seedbeds of greater economic productivity, competitiveness, and job creation

- ***Build the knowledge base necessary to address the nation's energy challenges*** The regional centers would collaborate with K-12 schools, community colleges, regional universities, and workplace training initiatives to educate future scientists, engineers, innovators, and entrepreneurs and motivate the region's graduating students to contribute to the Great Lakes emerging green economy

- ***Complement efforts at universities and across the DOE innovation infrastructure but be organizationally and managerially separate from either group.*** The regional energy centers would look beyond the pure basic science research at universities to focus much more on commercialization and deployment issues. Further, rather than duplicate the national labs' capacity for large-scale, infrastructure-intensive projects, these centers would utilize a different, collaborative translational research paradigm. And within DOE, the centers would occupy a special niche for bottom-up translational research in a suite of new, largely top-down innovation-oriented programs that aim to advance fundamental science (EFRCs), bring energy R&D to scale (Energy Innovation Hubs), and find ways to break the cost barriers of new technology (ARPA-E).

To establish and build out the institute network across the Great Lakes region, meanwhile, the new regional energy initiative would:

- ***Utilize a tiered organization and management structure.*** Each regional center would have a strong external advisory board representing the participating partners, including all levels of government, industry, universities, nonprofits, entrepreneurs, and investors. In some cases, partners might play direct management roles with executive authority

- ***Adopt a competitive award process with specific selection criteria.*** A competitive award process would designate centers 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 participating partners; strength of the center management plan; strategies for commercialization, including approaches to tech transfer and intellectual property issues; plans for connecting the proposed center to the surrounding regional industry cluster and the regional network

- ***Receive as much federal funding as major DOE labs outside the Great Lakes region.*** Given the massive responsibilities of the proposed Great Lakes energy research centers, 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. Additional investment in the Great Lakes network would come from state governments, business and industry, and other investors. One can imagine around six compelling regional research centers based on the credible industry-university concentrations

The bottom line: The new push would take a bold new approach to both the magnitude and character of national energy research.

V. Conclusion

In conclusion, America's national energy infrastructure—based primarily upon fossil fuels—must be updated and replaced with new technologies. At the same time, few regions in the nation are better equipped to deliver the necessary innovations than the troubled Great Lakes area.

For which reason, a resilient nation should move aggressively to build the proposed Great Lakes network of regional energy research and innovation centers.

Through such an intervention the federal government could catalyze a dynamic new partnership of Midwestern businesses, research universities, federal laboratories, entrepreneurs, and state and local government to transform the nation's carbon-dependent economy. Along the way, the nation could experiment with a dynamic new approach to leveraging for the nation's benefit a powerful regional innovation complex while renewing the flagging manufacturing economy of the Great Lakes.