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Centers of Invention: Leveraging the Mountain West Innovation Complex for Energy System Transformation

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America needs to transform its energy system to reduce its carbon intensity and make clean energy cheap. At the same time, the Intermountain West region (which includes Arizona, Colorado, Idaho, New Mexico, Nevada, and Utah) possesses a unique confluence of world-class innovation assets; varied energy resources; and unparalleled opportunities to build out next-generation energy systems.

To that end, the brief proposes that the federal government begin constructing a distributed Intermountain West network of federally-funded, commercialization-oriented, broadly collaborative energy research and innovation centers. Organized around existing capacities in a hub-spoke structure that links fundamental science with innovation and commercialization, these research centers would engage universities, industries and labs to work around specific energy themes to rapidly deploy new technologies to the marketplace, build the region's knowledge-base, and stimulate economic development. Selected competitively based on scientific merit and the strength of proposed management, financial, and commercialization plans, roughly four to six energy innovation centers could reasonably be organized in the Intermountain West with total annual funding between $1 billion and $2 billion.

"The nation should look once again to the Intermountain West and its world-class innovation assets as it seeks to work out a clean energy future."

I. Introduction

Over and over America has looked to the West to work out the future. In this thinly populated terrain, experiments could still be attempted and national agendas advanced more swiftly than in the congested East, so the federal government has sought breakthroughs of every kind in the Mountain region.[1]

In the West, giant dams now generate electricity in new ways. Major science research laboratories lead our nation's alternative energy program. And for that matter, military test sites, engineering programs, and research and development contracts with universities have contributed to a constant dynamic of radical invention in the Intermountain states. For a century and more, in short, the West has provided an inviting frontier for technological innovation and experimentation, and a powerful symbiosis between federal and Western resources has emerged there.

Now, as the nation works out another future—a clean energy future—in order to create a more competitive "next economy," it should look once again to the Intermountain West.

As in the past, a mutually beneficial synergy supportive of the nation's and region's interests appears not just possible but necessary.

America needs to transform its energy system to reduce its carbon intensity and make clean energy cheap. At the same time, the Intermountain West region (including Arizona, Colorado, Idaho, New Mexico, Nevada, and Utah) possesses a unique confluence of world-class innovation assets (research universities, national and corporate research labs, and top-flight science and engineering talent); varied energy resources ranging from low-sulfur coal to solar, wind, and geothermal energy potential; and unparalleled opportunities to build out next-generation energy systems, whether smart energy grids or energy efficient buildings, as future population growth demands the building of new infrastructure from the ground-up.

In view of that, this brief contends that a new partnership should be forged between the federal government and the Intermountain states metropolitan areas to leverage the region's unique strengths in support of the national interest.

To begin that partnership the federal government should construct in the Mountain region a distributed network of federally funded, commercialization-oriented sustainable energy research centers. These regional centers would combine aspects of the "discovery-innovation institutes" concept proposed by the National Academy of Engineering and the Metropolitan Policy Program at Brookings (as articulated in the Brookings paper "Energy Discovery-Innovation Institutes: A Step toward America's Energy Sustainability"); the "energy innovation hubs" being created by the U.S. Department of Energy (DOE); and the agricultural experiment station/cooperative extension model of the land-grant universities that has played such an important role in the growth of the West.[2]

In the spirit of the earlier land-grant university paradigm, the new network would involve the region's research universities and national labs and invoke strong participation from industry, entrepreneurs, and investors as well as state and local government. Each individual breakthrough center would have a different theme, though all would conduct focused translational research necessary to move fundamental scientific discoveries from the laboratory to commercialization to system-wide deployment.

Done correctly, these centers could be just as transformational as the construction of the major science-engineering-technology-military complex that the nation brought into being in the West during World War II and the Cold War. If created at the scale envisioned here, a new generation of high-powered university-industry-government clean energy innovation partnerships would have the power to catalyze the growth of a major new clean-energy economy in the region perhaps even more significant than the microchip and aerospace industries created by mid-century defense investments. At a minimum, seeding the aridlands with an array of high-intensity research centers would introduce a powerful model for linking national leadership and local capabilities in service of national and regional prosperity.

II. The Intermountain West Offers Many Strengths to Help Advance the Nation's Clean Energy Priorities

The Intermountain West possesses much of what the nation needs if it is to radically transform its energy systems by making clean energy cheap and ubiquitous.

Historically the nation's premier source of natural resources, the Intermountain West has a deep familiarity with non-standard energy resources and systems, ranging from low-sulfur coal and uranium to hydro-power, oil shale, and natural gas. By dint of that history, the region already has significant experience with siting and developing energy projects, bringing energy to market, and distributing it to customers—all of which can be leveraged in service of new renewable energy technologies as well.

In addition, the Mountain West states' shared practical and cultural experience of energy—dirty as well as clean—is joined to both a generally "green" ethos and a long-recognized pioneering attitude, interest in invention, and practical bent toward collaboration. Ratings

of states' environmental views regularly rank Arizona, Colorado, Nevada, and New Mexico among the "greenest."[3] Likewise, the historian Gerald Nash observes that "as an underdeveloped region the [the West has been] more open to experimentation than the older, more industrially developed regions of the East."[4]

And yet, beyond such "soft" assets the Intermountain West offers the nation unique strengths related to energy innovation—strengths that can contribute hugely to generating the technological breakthroughs required to de-carbonize the nation's economy. Among many others, the region's capacities and assets include:

- **Existing strength in federal R&D.** Federal agencies obligated roughly $8.6 billion to various Intermountain West academic and industrial entities in FY2006.[5] Most notably, DOE sent over 30 percent of its federal R&D obligations (approximately $2.4 billion) to the Intermountain West states in FY2006 and is the third largest federal funder of industrial R&D in the region.[6] Furthermore, the Intermountain West is home to at least 30 federal laboratories representing several federal departments ranging from Agriculture and Defense to Commerce, Energy, and Transportation.[7] Key regional energy research installations, and their FY2010 budget appropriations, include: the National Renewable Energy Laboratory (NREL) in Colorado, which received $256 million; the Idaho National Laboratory (INL) in Idaho, which received $1.1 billion; and the Los Alamos and Sandia National Laboratories (LANL and SNL, respectively) in New Mexico, which received $1.8 billion and $1.3 billion.[8]

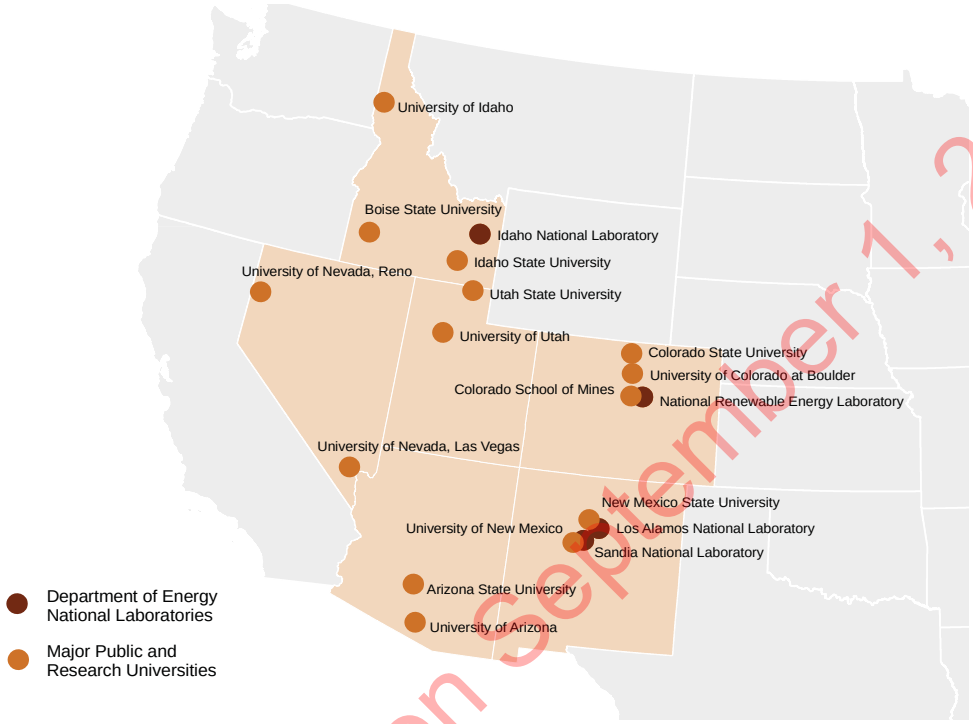
- **Breadth and depth of clean energy research activities.** Clean energy innovation activity is a robust and growing enterprise in the region. In Colorado, both NREL and the University of Colorado (CU) rank among the world's top 25 alternative energy research institutions with expertise in renewable resources, converting them to fuels or electricity, and commercializing their use in homes, businesses, and autos.[9] In New Mexico, SNL has longstanding experience investigating solar and wind technologies, energy storage, and fusion. The state's three other national laboratories—LANL, the Air Force Research Laboratory, and White Sands Missile Range—bring capabilities around fuel cells and hydrogen, high-energy lasers, and intensive testing and assessment services.[10]

A continued scan reveals an even wider range of significant energy innovation assets in the region. The University of Utah (U of U) leads the nation in DOE geothermal funding to universities and its research concentrations range from cleaner fossil fuel combustion and gasification to carbon sequestration.[11] Longstanding expertise in biomass and biodiesel resides at the University of Idaho (UI), where researchers invented one of the first recipes for converting vegetable oil to fuel.[12] Meanwhile, the nation's first integrated algal biorefinery is under construction in Southern New Mexico through a $100 million public-private partnership involving San Diego-based Sapphire Energy and all of the state's research universities and national labs.[13] And substantial capabilities for improving energy efficiency and consumption exist at UI's Integrated Design Lab, which is developing high-performance energy efficient buildings in Idaho and eastern Oregon, and at NREL, whose Colorado campus is an exemplar of sustainable development.[14]

Otherwise, strong capacity for nuclear energy innovation exists at LANL, SNL, and especially INL, DOE's lead nuclear R&D facility, and various university programs, including the University of Nevada, Las Vegas (UNLV), Idaho State University (ISU), the University of New Mexico (UNM). In these institutions, scientists and engineers work on topics like advanced fuel cycles and reactor upgrades, and tackle the experimental, computational, and engineering problems of putting materials under high pressure.[15]

And there is more. In the field of wind energy research, Boise State University (BSU) has a particularly strong focus on wind energy forecasting and research on energy storage for grid integration.[16] And in Colorado, NREL's National Wind Technology Center covers a wide spectrum of wind energy engineering disciplines, including at-

Intermountain West University and Laboratory Institutions with Clean Energy Innovation Resources



Source: Brookings Institution

mospheric fluid mechanics and aerodynamics; power systems and electronics; and wind turbine engineering applications.[17]

Finally in terms of solar R&D, Arizona State University (ASU) currently has over $15 million of research underway in Lightworks, an effort that consolidates all of the institution's light-based work from across a range of disciplines to address questions concerning artificial photosynthesis, solar-powered fuel conversion, and eventual applications to healthcare, computing, and beyond. Additionally, both the Arizona Research Institute for Solar Energy and the Solar Energy Initiative at UNLV engage in a full spectrum of basic research, modeling, demonstration projects, policy and market analysis, and technology transfer to better integrate the solar energy supply chain and tackle head-on cross-cutting implementation issues like storage, smart grid, photovoltaics, and building technologies.[18]

In sum, the Intermountain West possesses impressive breadth and depth across the clean energy innovation spectrum.

- **Wide-ranging collaborative research efforts.** Multi-institutional collaboration—a hallmark of current best-practice in innovation activity—is another strength of the region. For example, the Colorado Renewable Energy Collaboratory is a unique partnership between NREL, CU-Boulder, Colorado State University (CSU), and the Colorado School of Mines (CSM) to ramp-up research in wind, solar, biofuels (and in the near future, smart grid and carbon management) and accelerate the transfer of new technologies from the lab to the marketplace.[19]

The Center for Advanced Energy Studies is also a university-lab-industry partnership that joins Idaho's three major universities (UI, BSU, and ISU) and INL in R&D and commercialization ventures, complemented by public policy research into nuclear power, bioenergy, and advanced fossil fuels, among other areas.[20] Another regional example of broad multi-institutional collaboration is the Nevada Renewable Energy Consortium, which brings together the Desert Research Institute, the University of

Nevada at Reno (UNR), and UNLV to expand and coordinate the state's basic and applied research endeavors in wind, solar, and geothermal sciences.[21]

Specifically focused on clean coal technology, the Eastern Utah Secure Energy Partnership brings into collaboration a variety of institutions, including the U of U, Utah State University, INL, Oak Ridge National Laboratory, state and local governments, and private companies such as CB Bioenergy, Ceramatec, and Luca Technologies.

In geothermal, BSU led a consortium involving UNR, U of U, and several out-of-region partners in establishing the National Geothermal Data System, a central repository for geothermal and related data.[22] Similarly, the Power Systems Engineering Research Center led by ASU is a large university-lab-industry consortia, involving 13 universities, three national labs, and 37 industry members in the pursuit of building modern electricity infrastructure. Also in Arizona, the Solar Technology Institute funds several industry-academia solar research and commercialization initiatives, involving such partners as ASU, University of Arizona (UA), SNL, NREL, Simmons, Nanovoltaix, General Plasma, and other private sector firms.[23] Additionally, BSU's wind energy research (mentioned above) actively involves partners from INL, Idaho Power Company, Bonneville Power Administration, and John Deere Renewable Energy, to name a few.[24]

- **Growing and diverse private sector energy innovation investments.** Private sector innovation activity is also accelerating. Many of the Intermountain West states have clean energy sectors that may be relatively small compared to their overall state economies but rank among the fastest growing in the nation.[25] Indeed, Idaho's clean energy job growth of 126 percent between 1998 and 2007 led the nation. New Mexico (with a growth rate of 50 percent) also ranked among the top 10 states, with Nevada (29 percent), Arizona (21 percent), and Colorado (18 percent) following closely behind in the second quintile.[26] Moreover, Arizona, New Mexico, and Nevada rank first, second, and fourth, respectively, among the nation's "solar manufacturing" states, according to *Business Facilities Magazine*.[27] And on wind power manufacturing Nevada ranks fifth.[28]

In particular, New Mexico and Arizona have an especially strong showing of solar companies, with the former home to a number of established and new firms, including Emcore, Schott North America, and Solar Distinction, and the latter containing the operations of such industry leaders as First Solar, Kyocera, and Stirling Energy Systems, as well as a new, innovative company called REhnu. For its part, Colorado also has a number of solar start-ups, like Abound Solar and Ascent Solar, and is a leader in the wind industry, having quadrupled the amount of wind power on the state grid since 2006 and currently hosting at least 15 major wind companies, including the Siemens Wind Turbine Research Center, and the powerhouse, Vestas, which manufactures blades, towers, and nacelles in the state.[29]

Utah—despite a slight contraction in its clean energy economy between 1998 and 2007—hosts a broad range of small alternative and renewable energy companies plus a number of others that manufacture components for clean energy technologies like electric vehicles and various types of solar systems. Likewise, Idaho has numerous clean energy start-ups and small businesses engaged in a range of activities, such as solar, wind, geothermal, hydropower, and energy efficiency. Further, a recent DOE loan guarantee to nuclear power developer Areva will help bring on-line a new Idaho-based uranium enrichment facility using advanced centrifuge technologies.[30]

Finally, Nevada resides at the forefront of geothermal industry expansion, with leading firms like Ormat Technologies, Ram Power, and Vulcan headquartered in Reno and 86 projects with a cumulative final generation capacity of 2,000 to 3,700 megawatts—more than any other state—in various stages of development.[31] The Nevada utility NV Energy has committed to expanding a north-south transmission grid from Reno to Las Vegas that would allow more renewable power to come

on-line from the geothermal sources abundant in the north and the solar sources abundant in the south.[32]

- **Abundant supplies of native sustainable energy resources to support further energy innovation investments.** Adding to the innovation prospects in the region is a varied renewables resource base that provides the region unique opportunities for "learning by doing" and deployment. All of the Intermountain West states rank within the top 10 nationally for their solar power potential, with Nevada, Arizona, and New Mexico having the greatest.[33] In addition, all six of the Intermountain West states are among the 13 nationally that have located moderate- and high-temperature geothermal resources on private or accessible public lands.[34] And three states—Colorado, New Mexico, and Idaho—rank among the top 15 nationally with regard to wind energy potential.[35]

- **State regulations and initiatives favorable to clean energy innovation and market adoption.** Equally important is the region's supportive state policy environment. All of the Intermountain West states offer state-level clean energy financial incentives, such as residential, commercial, or industrial loan, rebate, or tax incentives. Four of the states—Arizona, Colorado, New Mexico, and Nevada—apply renewable portfolio standards to their utilities. And, three states (Colorado, New Mexico, and Nevada) also have energy efficiency resource standards for their utilities.[36]

  Additionally, the Intermountain West boasts some signature state-led policy initiatives. For example, recently passed legislation in Colorado requires coal-fired power plants to be gradually replaced or retrofitted with facilities using natural gas.[37] In Utah, the USTAR (Utah Science Technology and Research) Initiative provides significant state funding for research in carbon engineering, biofuels, renewable power generation, and building technologies. And in New Mexico, the state-led Green Grid Initiative—a massive undertaking involving the state's two DOE labs and three research universities, as well as five utilities, ten Fortune Global 500 companies, and Japan's energy research agency—aims to build out a grid system that fully incorporates renewable generation and enables real-time data on energy consumption and demand.[38] Another large effort is Idaho's Strategic Energy Alliance, whose purpose is to develop a sound energy portfolio for Idaho.

  State efforts like these to drive demand for renewables and encourage deployment are widely believed to be an important part of the innovation mix.

- **Other established industries relevant to clean energy.** Finally, a number of the region's non-energy industrial strengths appear highly relevant to clean energy development. The region's experience in water management and treatment technologies is valuable in considering the purification and reuse of water in energy production. Further, the Mountain West's established aerospace industry provides a platform for testing clean aviation fuels, like those based on algae, and developing new composite materials that also have clean energy applications. Additionally, the state-of-the-art super computing capabilities established across the Intermountain West region may prove quite valuable in processing real-time and archival renewable energy data for public consumption.[39]

In short, the Intermountain West states and metropolitan areas—home to a longstanding federal/Western collaboration on energy and technology issues—hold out to the nation powerful capabilities in the energy innovation field.

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

America as a whole, for its part, 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, the price gap between conventional energy sources like fossil fuels and clean energy sources remains too wide to catalyze full energy-system innovation, since companies do not face a financial incentive to commit to clean and efficient energy technologies and processes over the long haul. A national problem, the struggle to commercialize clean energy innovation is further exacerbated in the Intermountain West, where great research exists, but private sector capital is in more limited supply than in the coastal hubs of Silicon Valley and Boston. 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 may be further delaying innovation. Fourth, the benefits of regional industry clustering, which include knowledge spillovers and other cross-fertilizations that facilitate 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 R&D by the health care sector, the 2.4 percent by agriculture, and the 10 percent by information technology and pharmaceutical industries.[40]

The national government's efforts to respond to the nation's energy research shortfalls are 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 recent federal baseline appropriation level of around $3 billion a year for non-defense energy-related R&D simply remains too small. Such a figure remains 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.[41]

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. The Intermountain West states, for their part, were awarded over $1 billion for environmental management purposes like clean-up around nuclear facilities, and $631 million to work on electricity delivery and energy reliability issues like smart grid implementation.[42] However, ARRA was a one-time injection that cannot be counted on to sustain federal energy R&D at the necessary level into the future.

Relatedly, three other relatively recent DOE programs, the Energy Frontier Research Centers (EFRCs) effort, the Advanced Research Projects Agency–Energy (ARPA-E), and the signature Energy Innovation Hubs initiative related to the Brookings e-DIIs idea have also put in place new avenues for federal energy investments. Currently, seven of the 43 operating EFRCs are located in the Intermountain West states of Arizona, Colorado, Idaho, and New Mexico, conducting work in bio-inspired solar fuels, nuclear energy, and

solid-state lighting, among other issues.[43] Another nine projects in Arizona, Colorado, and Utah received ARPA-E funding for work on carbon capture, energy storage, and biodiesel.[44] And the winning consortium for DOE's innovation hub focused modeling and simulation for nuclear reactors includes among its partners the Intermountain West institutions of INL, LANL, and SNL.[45] However, with EFRCs comprised only of small group projects, ARPA-E oriented to "disruptive" basic research, and only a total of four hubs yet funded, none of these initiatives alone has the scale or 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 underutilized resources. With so many of their activities kept isolated from the private sector and fragmented, those labs whose primary missions are pure energy research 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.[46]

Most notably, many 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. New research and commercialization paradigms are imperative. A perfect example of the need for integrated, cross-disciplinary, and multi-pronged research approach is the build-out of a smart energy grid for the 21st century. Such a vast technology upgrade requires tackling multiple issues at once, such as integrating renewable generation capacities; improving energy storage and transmission; advancing demand response technologies; optimizing energy efficiency; developing public policies to build-out required infrastructure; demonstrating grid management projects in cooperation with different communities; and regulating standards for grid security, reliability, and self-sufficiency in case of emergencies. Without addressing all of these matters, the nation will not be able to realize the promise of what is touted as a next generation necessity.

With that said, it should be noted that in the Intermountain West two of the region's DOE laboratories, INL and NREL, are already taking a systems approach to energy research, development, and deployment, with missions that extend from concept to technology transfer, and on through commercialization. NREL, for example, employs hundreds of partnerships to help drive its market-facing approach, and, in 2009, engaged in over 350 active partnerships of which 140 were cooperative R&D agreements—more than any other lab in the DOE system. In this way, the Mountain West region has within it several collaborative and holistic models DOE needs to institutionalize.

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 Intermountain West, 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 solar, wind, and geothermal; and the region's growing base of clean energy companies offering new 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 to bring 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-embedded Intermountain West energy research centers organized in a hub-spoke structure to link fundamental scientific discoveries with technological innovation and commercialization.[47]

Originally introduced in the Brookings policy proposal, "Energy Discovery-Innovation Institutes: A Step Toward America's Energy Sustainability," a nationwide network of these energy innovation 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 and regional economies.

In the Intermountain West, specifically, a federal move to jumpstart the process with a series of roughly four to six of these high-powered, market-focused breakthrough institutes could strategically situate centers 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 proposed energy innovation centers network 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 Intermountain West innovation institute would undertake a different focus, such as renewable energy technologies, geothermal resources, fuel cells, carbon management, and energy grid and deployment issues. In addition to translational science and technology research, the centers would also facilitate the realization of critical energy innovation "outcomes" by simultaneously focusing on policy issues like regulatory frameworks and utility rules and business planning needs, like raising capital investment.

- **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, Southern Nevada and Arizona could host a regional solar energy innovation center to work on the entire **solar supply chain** from cells and storage to grid integration and demonstration projects by bringing together Nevada partners such as UNLV, NV Energy, Nellis Air Force Base, and private solar developers like Acciona and Solar Millennium, as well as Arizona and Mountain West partners like ASU, UA, UNM, SNL, and NREL. This idea aligns well with the recent commitment by DOE to turn a former nuclear site in the Nevada desert into a new Solar Demonstration Zone to serve as proving grounds for new solar technologies and a critical link between advanced technology development and full-scale commercialization efforts.[48]

  Moreover, across Colorado and New Mexico, institutional partners could embark on several major regional collaborations, including one focused on **advanced biofuels** involving the Colorado Collaboratory, ConocoPhillips, New Mexico State University, the Center of Excellence for Hazardous Materials Management, and smaller companies in both states that work on algal fuels, advanced alcohols, and solar-powered gasification of biomass. Another Colorado-New Mexico collaboration might center on advancing a smarter, **integrated energy grid** and could involve the UC,

Four To Six Energy Research and Innovation Centers Could be Housed in the Intermountain West Region

Proposed Center Focus	Proposed Center Geography	Potential Partners
Solar energy	Southern Nevada-Arizona	Institutions from across the Intermountain West: the University of Nevada, Las Vegas, Arizona State University, the University of Arizona, and the University of New Mexico; federal institutions like Nellis Air Force Base, NREL, and Sandia National Lab; and private sector players like NV Energy, Acciona, and Solar Millennium
Advanced biofuels	Colorado-New Mexico	New Mexico State University, the Colorado Collaboratory, the Center of Excellence for Hazardous Materials Management, and private companies like ConocoPhillips and smaller niche firms
Integrated smart grid	Colorado-New Mexico	The University of Colorado, Colorado State University, and the University of New Mexico in collaboration with the NREL and private companies such as Lucent, Cisco, Lockheed Martin, and Tres Amigas
Geothermal research and commercialization	Northern Nevada-Utah-Idaho	The Great Basin Center at the University of Nevada-Reno, the University of Utah, and Idaho State University; the Idaho National Laboratory; and private firms like Ormat Technologies, U.S. Geothermal, and TerraTek
Carbon management and carbon capture and sequestration research	Idaho-Utah-Colorado	The Universities of Idaho and Utah, the Colorado School of Mines, and private companies such as Headwaters Clean Carbon Services and GoNano Technologies
Nuclear energy, including modular reactors and new production and waste-management systems	Intermountain West region-wide	Partners from across the Intermountain West: Idaho, Sandia, and Los Alamos National Labs; UNLV and the Universities of Colorado, Idaho, and New Mexico; and regional nuclear power producers, providers and plant operators

Source: Brookings Institution

CSU, NREL, the UNM, Lucent, Cisco, Lockheed Martin, and the Tres Amigas project aimed at linking three major U.S. grid systems.

A regional **geothermal research and commercialization** center, for that matter, could draw in partners from Northern Nevada, Utah and Idaho, including UNR's Great Basin Center, University of Utah, ISU, INL, and private companies like Ormat Technologies, the world's only vertically-integrated geothermal power provider, U.S. Geothermal, Inc., a geothermal project developer, and TerraTek, which operates a geomechanics laboratory center of excellence. Additionally, a regional collaboration on **carbon management** and carbon capture and sequestration research could also involve Idaho, Utah, and Colorado partners, including the UI, U of U, and CSM, and private companies like Headwaters Clean Carbon Services that is developing sequestration sites and GoNano Technologies that is working on carbon capture and recycling.

Another possibility exists for a regional energy research center focused on **nuclear power** issues like small, modular reactors, and systems for producing very high-temperature hydrogen and transmuting high-level radioactive waste. As a region-wide effort, this center could draw on partners across the Intermountain West, including the lab expertise at INL, SNL, LANL, the university researchers at UNLV, UC, UI, UNM, and various regional nuclear power producers, providers and plant operators.

In these and other e-DII 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") around the region, nation, and world through exchanges of participants, regularly scheduled meetings, and advanced information and communications technology. The goal would be to connect related work, enhance the coordinated pursuit of larger national goals, and limit unnecessary duplication of efforts and cumbersome management bureaucracy.

- **Develop and rapidly deploy highly innovative technologies to the market.** Rather than aim for revenue maximization, technology transfer in the e-DIIs would be structured to maximize the volume, speed, and positive societal impact of commercialization. As much as possible, the e-DIIs 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 e-DII 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—the new energy commercialization institutes would facilitate cross-sector knowledge spillovers, innovation exchange, and accelerated 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 proposed centers also 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 Mountain metropolitan areas' emerging green economy.

- **Complement efforts at universities and across the DOE innovation infrastructure but be organizationally and managerially separate from either group.** The 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, the new institutes would utilize a different, collaborative translational research paradigm. And within DOE, the energy centers would occupy a special niche for bottom-up translational research amidst the department's suite of new, largely top-down innovation-oriented programs such as the EFRCs, ARPA-E, and energy innovation hubs.

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

- **Utilize a tiered organization and management structure.** Each energy institute 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 new centers for federal support and inclusion in the Intermountain West 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 center; strength of the center management plan; ability to establish long-term financial sustainability; strategies for commercialization, including approaches to tech transfer and intellec-

tual property issues; and plans for connecting the proposed institute to the surrounding regional industry cluster and the regional and national center network.

- **Receive as much federal funding as major DOE labs.** Given the massive responsibilities of the proposed Mountain West energy 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 Intermountain breakthough network would come from state governments, business and industry, and other investors. One can imagine around four to six compelling centers based on 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

The Intermountain West region is poised to help reinvent America's fossil-fuel dependent energy system and so construct the "next economy" in the Mountain region and nationally.

The nation should move proactively and aggressively to build the proposed Intermountain West network of high-powered energy innovation commercialization centers.

Through such an intervention, the federal government could catalyze a dynamic new partnership of Mountain West 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 helping to empower the Intermountain West to reach its potential for prominence in a "next economy" that will be opportunity-rich as well as export-oriented, lower-carbon, and innovation-fueled.

Endnotes

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About the Metropolitan Policy Program at the Brookings Institution

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Brookings Mountain West

Established in 2009 as a partnership between the Brookings Institution and the University of Nevada, Las Vegas (UNLV), Brookings Mountain West (BMW) seeks to bring high-quality independent and influential public policy research to the critical issues facing the dynamic metropolitan areas of the Mountain West region. In this, the new initiative builds upon the work of Brookings' Metropolitan Policy Program, which focuses on helping metropolitan areas like Las Vegas grow in robust, inclusive, and sustainable ways through attention to the fundamental drivers of prosperity such as innovation, infrastructure, human capital, and quality of place, as well as regional governance. Along those lines, BMW, along with partners throughout the Mountain West, takes a deep interest in such areas as infrastructure improvement, economic growth, demographic change, environmental impact, alternative energy, and real estate investment.

As the Mountain West emerges as a new American Heartland, it will play an increasingly significant role in shaping national policy discussions. BMW provides a forum for this dialogue and offers knowledge-based policy solutions to help improve the quality of life in the West. Learn more at http://brookingsmtnwest.unlv.edu/

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