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CENTER FOR CLEAN ENERGY INNOVATION

US State and Regional Energy Innovation Index

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Vibrant regional energy innovation ecosystems are important for any national net-zero strategy. But to understand the potential contributions they can make to the price and performance of clean energy technologies, we must first benchmark the resources they bring to bear.

KEY TAKEAWAYS

- A diverse array of new and improved energy technologies that emit far fewer greenhouse gases, while matching (or nearly so) the price and performance of incumbent technologies, are needed to reduce the harms of climate change.
- State and regional energy innovation ecosystems in the United States can and should make significant contributions to the development and improvement of these technologies.
- Recent legislation has established federal policies to strengthen these ecosystems. Many states and regions are responding to this opportunity by adopting clean energy-based economic development strategies.
- The ITIF U.S. State and Regional Innovation Index provides a baseline against which to measure the future impact of this legislation at the state and regional level. It covers 9 categories of innovation system functions and 14 areas of technological specialization.
- The federal government should continue to support state and regional capacity-building for clean energy innovation so that bottom-up strategies stand a better chance of success. Federal programs should strengthen coordination with one another.

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INTRODUCTION

The United States, along with the rest of the world, has embarked on a transition to clean energy. The transition's ultimate endpoint is net-zero greenhouse gas (GHG) emissions to limit the impact of climate change. Energy security, human health, local environmental protection, and economic opportunity also motivate the global community to pursue this important objective. But the path to net zero is strewn with obstacles. Many of the technologies the world needs to stay on it are too expensive, perform too poorly, or are simply unavailable right now. Innovation should therefore be a major focus of any net-zero strategy.[1]

Regional energy innovation ecosystems have great potential to contribute to such strategies. Geographically concentrated networks of technology and service firms, research institutions, and nonprofit and public sector entities could drive price and performance improvements in a diverse array of clean energy sources and uses. This report assesses the potential of energy innovation ecosystems across the United States to contribute to this important mission, drawing on a wide range of data, such as federal and private funding, publications and patents, and state and regional policies and public opinion, covering nine categories of innovation system functions, to compile an index of this potential. Fourteen technology-specific indices, which draw on subsets of the main database, complement the main index and highlight regional diversity.

The index, while inevitably imperfect, provides a baseline against which to measure the future impact of recent federal legislation. Landmark bills passed by Congress in 2021 and 2022 support states and regions that seek to strengthen their energy innovation ecosystems. Quite a few states and regions had already begun to do so before the new federal programs were created, and many more are now responding to these opportunities. The report concludes by offering broad suggestions for sustaining this momentum and improving the odds that the new policies will succeed.

REGIONAL INNOVATION ECOSYSTEMS: ENGINES OF THE ENERGY TRANSITION

Abundant, affordable, reliable energy is a fundamental requirement of a high standard of living. A small handful of individuals, following Thoreau, may choose a life of voluntary simplicity, but the vast majority of the world's population seeks the comforts and opportunities that are widely available in high-income countries. While these need not be supplied as wastefully as they are now, especially in the United States, they intrinsically demand substantial energy inputs.

The Industrial Revolution, which brought for the first time a measure of comfort and opportunity to a large proportion of the population in the places it swept through, rested on energy from fossil fuels. That pattern continues today, with these same fuels providing about 80 percent of global primary energy. They remain abundant and reasonably affordable and reliable, but the social costs of burning them have mounted. Most notably, fossil fuel combustion accounts for about 75 percent of the GHG emissions that are driving catastrophic storms, wildfires, and other symptoms of global climate change.[2]

The challenge facing human civilization, then, is to enable all those who desire to live at a high standard to have the quantity and quality of energy they need to do so, while simultaneously and dramatically reducing the harm that would cause. As Gaster, Atkinson, and Righter argue, new and improved energy technologies that emit far fewer GHGs, while matching (or nearly so) the price and performance of the incumbents, lie at the core of any strategy with any chance of surmounting this monumental challenge.[3]

A diverse array of such innovations are needed. Some, such as solar panels and heat pumps, are well advanced, though still capable of significant improvement. Many others, such as green steel and carbon dioxide (CO_2) removal, are early in their development. Many of these new technologies are complex systems themselves, and nearly all must be further integrated with even more complex systems, such as the power grid.[4]

Energy innovation is a subject of discussion in international climate talks and figures into many national policies. Some national governments are making important contributions by funding clean energy research, development, and demonstration, fostering climate-tech venture investments, and the like. But the innovation rubber really hits the energy transition road at the regional level. That's because innovation, especially innovation in complex systems, accelerates most quickly when dense networks of firms and supporting institutions, clustered in relatively compact geographic areas, pursue it.[5]

The concept of regional innovation ecosystems is an old one, dating back to the 19th century economist Alfred Marshall, who noted "something in the air" in places such as Sheffield, where Britain's pioneering cutlery makers were concentrated. Modern research has revealed that "something" to have many elements: When working effectively, regional innovation ecosystems foster knowledge exchange, attract specialized labor, facilitate infrastructure investment, and encourage entrepreneurship, among other things. Regions diverge economically in large part because of these ecosystems. Some are home to innovative industries that serve growing markets beyond the regions in which they are located, while others rely on stagnant or shrinking sectors. Silicon Valley and Detroit epitomize these extremes in the public mind.[6]

Digitalization might have been expected to undermine these dynamics, but, as many analysts have noted, "the death of distance has been greatly exaggerated." Van der Wouden and Youn, for

instance, find that while the geographical distance between research collaborators grew substantially between 1975 and 2015, so had the "learning premium" associated with geographical proximity. Those who collaborated locally were far more likely to enter new fields and build their own capabilities than those who collaborated long distance. The effect was especially strong in STEM (science, technology, engineering, and math) disciplines, such as chemistry, materials science, and engineering, which are particularly important in energy innovation.[7]

The systemic nature of energy innovation heightens the importance of collaboration within regions. Innovative low-carbon power, transportation, and industrial systems typically involve diverse components that must be integrated carefully to optimize performance and minimize cost and emissions. These integration processes, in turn, often require learning-by-doing and learning-by-using across organizational and institutional boundaries. Geographic proximity is likely to ease them by facilitating hands-on and face-to-face interactions.[8]

The importance of regional energy innovation ecosystems in the coming decades will be heightened by the vulnerability to disruption of places dependent today on fossil-fuel-based industries. Wyoming's coal mines, Houston's petrochemical plants, and Detroit's auto factories are among those at risk. Hanson, a co-author of 2016's "The China Shock" paper (a belated recognition of that epochal impact by neoclassical economists) wrote that "the energy transition … is a shock foretold" for such regions.[9]

Whether such "brownfield" regions are willing and able to repurpose their existing assets or build new ones to seize the opportunities presented by the transition will go a long way toward determining their future economic dynamism in a low-carbon world. Wyoming's effort to position itself as a leader in nuclear power and carbon capture, Houston's push to become a hydrogen hub, and Detroit's emerging shift to electric vehicles illustrate these dynamics. Of course, such retooling regions must frequently compete with "greenfield" locations elsewhere, domestically and globally.[10]

That competition has important consequences for the energy transition. If regional innovation ecosystems are able to lower the cost and improve the performance of emissions-reducing technologies, their uptake will expand, feeding ideas and resources back to the regions that make them. This virtuous cycle extending beyond the region will be enhanced and enabled by international agreements and national policies, but ultimately depends on positive feedbacks within the region among laboratories, factories, testbeds, and related facilities, organizations, and institutions.

FROM TBED TO CEBED: THE REGIONAL MOMENT IN U.S. ENERGY AND CLIMATE INNOVATION POLICY

Some regional innovation ecosystems specializing in low-carbon technology have emerged relatively spontaneously. Wind energy innovation revitalized Denmark's central Jutland region, for instance, repurposing older manufacturing assets beginning in the 1970s and later fending off higher-tech competitors elsewhere. Others have been built up more deliberately. The solar power manufacturing cluster in China's Yangtze River Delta was created in the 2000s in large measure by targeted local, provincial, and national policies.[11]