Chairman Murkowski, Ranking Member Manchin and Members of the Senate Committee on Energy and Natural Resources, thank you for the opportunity to appear before you today to discuss the future of energy innovation in the United States.

It was my pleasure to appear multiple times before this Committee during the time I had the honor of serving as the 13th U.S. Secretary of Energy. Throughout my time of service, I found that Members of the Committee from both sides of the aisle came together on numerous occasions to support U.S. energy innovation. I hope that the 116th Congress will continue this tradition.

Much of my career has focused on energy innovation. At MIT, I established the MIT Energy Initiative, which had a significant focus on innovation in a carbon-constrained environment and engaged all of MIT’s Schools. As Secretary of Energy, I made clean energy innovation a cornerstone of the Department’s initiatives and policy. And now, at the Energy Futures Initiative, clean energy innovation is a pillar of our policy analysis. EFI has produced policy papers on important elements of energy innovation, including the national security foundation for the commercial nuclear energy sector; implementation of the 45Q tax credit program for carbon capture, utilization and storage; expanding the DOE Loan programs to leverage increased innovation in energy infrastructures; and application of blockchain technology to management of energy systems and services.

Importance of Energy Innovation

Energy innovation is the essence of America’s security and strength. Our ability to innovate is at the heart of American economic success and optimism. Innovation drives job creation, contributes to national security, addresses complex societal challenges and improves our quality of life.

For the past seven decades, the United States has been the global leader in technology and energy innovation. Central to U.S. leadership in innovation is our unparalleled innovation ecosystem which includes the Federal, state, local and tribal governments; national laboratories; research universities; the private sector; nonprofits and philanthropies.
The U.S. is undergoing rapid change in the global competitive environment, challenging America’s preeminent position but also offering immense opportunity for shaping the inevitable low-carbon global energy future. The science is clear, and the data are compelling—climate change is a major threat to our planet and to our way of life, and the clock is ticking. Nations in denial of climate change as a critical driver of an accelerated clean energy transformation will be left behind.

Accelerating this transformation won’t be easy: the U.S. energy system has considerable inertia and risk aversion, since the industry is highly capitalized and must provide essential services all the time. This creates an inherent tension between the energy incumbents and the technology disruptors that must instead be harnessed to advance innovation, with incumbents and disruptors each playing an essential role.

**Accelerating the Pace of Energy Innovation**

It is in this context that the Energy Futures Initiative and IHS Markit undertook a joint study of the U.S. energy innovation landscape, commissioned by Breakthrough Energy. Yesterday we released the final report, *Advancing the Landscape of Clean Energy Innovation*. Breakthrough Energy asked my colleague and friend Dan Yergin and me to co-chair the study, drawing on our complementary private sector and public sector perspectives on the current U.S. clean energy innovation landscape, with the goal of defining a strategic path forward of national scope. The Executive Summary of the report is attached for inclusion in the hearing record.

Clean energy innovation supports multiple national goals: economic competitiveness, environmental responsibility, energy security and national security. The report describes today’s U.S. ecosystem of clean energy innovation from the perspectives of technological potential, investment patterns, institutional roles and public policy. *Advancing the Landscape of Clean Energy Innovation* provides recommendations for accelerating our progress toward a clean energy economy.

Our study was comprehensive in scope, addressing technologies with breakthrough potential; the role of regional clean energy ecosystems; mobilizing increased private sector investment in energy innovation; and the respective roles of federal, state, local and tribal governments. Based on our assessment of the strengths and weaknesses of the clean energy ecosystem, we developed 18 major recommendations for making the ecosystem more effective.

A key finding is the need for increased, and better targeted, public and private sector investment in energy innovation across all stages of the innovation spectrum from fundamental research through commercial scale demonstrations. The study team developed a methodology and set of criteria to examine current and proposed energy technologies for their breakthrough potential. The report examined more than 100 cutting edge energy technologies, focusing on the candidates with significant breakthrough potential, including: advanced energy storage technologies; advanced nuclear reactor technologies; new approaches to decarbonization of industrial processes; electricity systems
modernization with a focus on the role of grid modernization in enabling smart communities; and large-scale carbon dioxide utilization and management, including new approaches for carbon dioxide removal from the environment where emissions are not otherwise averted or mitigated.

Several groups, including the American Energy Innovation Council made up of large American company CEOs, have argued for tripling federal clean energy investment. This is important, but more than increased funding is needed. The federal energy innovation portfolio—indeed the portfolio across the entire innovation chain—needs to be “all of the above” to match the time scales and geographies and to emphasize optionality. History shows that we achieve better results when flexible innovation pathways are favored over planned, prescriptive outcomes.

The report recommends that the private sector allocate increased investment from the tax savings created by the Tax Cut and Jobs Act to energy innovation, with a particular focus on testing facilities for product demonstration. The analysis also makes clear that disciplined public-private partnership is needed across the innovation value chain to demonstration and initial commercial deployment of critical technologies. The report also recommends a stronger role for strategic philanthropic investors in alignment with government and industry.

The report highlights the need for the federal energy innovation research portfolio to be better managed for performance, regardless of the appropriated amounts. A key focus is the Department of Energy, which in FY 2016 administered three-quarters of Federal investment in clean energy innovation. Other agencies with significant clean energy innovation budgets include the Department of Defense (DOD), the Department of Transportation (DOT), and the Department of Agriculture (USDA); portfolios at these agencies are mission-focused, as opposed to being broadly based across all energy sectors.

The report notes that DOE’s applied energy research programs are currently organized around a fuel-centric framework that has its origins in the 1970s, a structure that inherently skews its programs and budgets. The current structure also lacks clear direction for supporting all stages of the innovation process from fundamental research through commercial demonstration. A federal system that is focused solely on discovery and invention leaves the door open to other countries to translate the fruits of this research into new products, industries and jobs that are based offshore.

During my tenure as Secretary, I advanced clean energy innovation as the cornerstone of our national energy policy. We combined the science and applied energy R&D portfolios under a single Under Secretary to enable more seamless translation of fundamental science into new energy technologies. We incorporated innovation into the two installments of the Quadrennial Energy Review, a government-wide effort that integrated the energy-related interests of 22 federal agencies. Congressional action on many of the energy infrastructure recommendations demonstrated the broad appeal of analytically grounded policy development. We also updated the Quadrennial Technology Review. We placed particular focus on the role of the DOE National Laboratory system. We created a Laboratory Policy Council to engage the Laboratories in a stronger strategic relationship with Departmental policies and
programs, established a Laboratory Operations Board to promote more efficient and effective laboratory operations, created the Office of Technology Transitions to accelerate the transfer of new technologies to the private sector and produced the first State of the National Laboratories report. We analyzed the importance of regional innovation systems and our last budget request sought funding for regional structures.

On the international scale, DOE led efforts to revamp and modernize the G-7/EU Energy Security Principles, which provided a focus on the importance of clean energy to energy security. DOE also was in the forefront of the establishment of Mission Innovation, an initiative supported by 23 countries plus the European Commission to double the level of public investment in energy technology innovation over five years.

The report builds on this foundation and expands the focus to all levels of government to align key policies, players and programs in ways that both enhance and accelerate clean energy innovation. At the federal level, the report notes that the fuels-based organizational structure of DOE, which has been in existence since 1979, is not optimized for modern energy systems and needs. It tends to lead to budget allocations by fuel, resulting in gaps and budget distortions, rather than prioritization by innovation potential.

A good case in point is DOE funding for RD&D on advanced grid-scale energy storage technologies. The budget requests for energy storage R&D in each of the past two fiscal years was only $8 million for this key technology area. Congress increased the grid-scale energy storage budget in the electricity office significantly, to $41 million in FY 2018 and $46 million in FY 2019; yet it remains underweighted within a $5 billion total DOE energy RD&D investment portfolio when one considers the needs all the way to seasonal storage. A serious gap currently exists for carbon dioxide removal RD&D (including biological sequestration), which has no obvious organizational home within the current DOE organizational structure, and consequently is not funded at a level commensurate with its need and long-term potential.

The report’s assessment of the current landscape in the energy innovation space was not limited to DOE or the federal government. States, cities and tribal governments play a very important role in the energy innovation process, particularly as supporters of initial commercial adoption of new energy technologies and products. It recommends increased focus on identifying and spreading the use of best practices among the states, and closer alignment of federal and state financial incentives to maximize effectiveness. Expanded policy innovation in state electricity and natural gas regulatory practices also could play an important role in accelerating energy innovation.

The report also notes the importance of nurturing energy innovation ecosystems at a regional scale. Energy resources, expertise and markets vary significantly by region of the country, and many of the issues facing the energy sector can be better managed by strategies tailored to each region’s specific needs. Many energy innovation clusters have emerged in the U.S. and are evolving into fully-integrated
innovation ecosystems, and federal policies and programs should be cognizant of these developments and seek to nurture further evolution. The DOE National Laboratories and other federally-funded research institutes, working with universities, can play a major role in catalyzing regional energy innovation ecosystems.

A key finding underpinning the work of the study team was the emergence of new technologies outside the energy arena that can enable further innovation in energy applications. Technological developments in digitalization, big data analytics, advanced computing, smart systems, additive manufacturing and robotics have opened the door to a potential new wave of innovation in the energy economy. Combined with socio-economic trends in urbanization and flattening of energy demand, they point to new opportunities for energy innovation, for the emergence of new companies and whole new industries in the energy sector, creation of new and better jobs, new consumer services, more cost-effective energy use and a deeply decarbonized 21st century energy economy.

Conclusion

All of this work points to the need for, and ability of the U.S. to sustain its preeminence in clean energy technology innovation but requires far-sighted and sustained action to better align the policies, players and programs that are the key building blocks of our national energy innovation ecosystem.

It is my pleasure—once again—to appear before this important Committee. I have always found that Senators from both sides of the aisle work together to support US energy innovation.

Chairman Murkowski, Ranking Member Manchin and Members of the Senate Committee on Energy and Natural Resources, thank you for the opportunity to appear before you today to discuss the future of energy innovation in the United States. I look forward to your questions.

Attachment: Advancing the Landscape of Clean Energy Innovation, Executive Summary, February 2019
Advancing the Landscape of Clean Energy Innovation

Executive Summary
February 2019
Foreword

We are pleased to submit our report, “Advancing the Landscape of Clean Energy Innovation.” In this report we describe today’s U.S. ecosystem of clean energy innovation from the perspectives of technological potential, investment patterns, institutional roles, and public policy.

The report identifies critical strengths and weaknesses of this ecosystem and offers recommendations for making that ecosystem more effective. It examines the different technology readiness stages through which innovation passes and the importance of feedback among those stages. It also discusses the significant opportunities to accelerate the pace of clean energy innovation that are presented by rapid advances occurring today across a myriad of technologies originating outside the energy sector.

We would like to emphasize three observations from our report.

• First, the U.S. has shown over many decades an unparalleled capacity to nurture energy innovation. This capacity reflects a rich and durable collaboration among government, universities, research institutions, industry, and entrepreneurs. This collaboration is grounded in the belief that energy innovation contributes importantly to economic growth, energy security, and environmental stewardship.

• Second, even with our capacity to innovate, and even with the emergence of innumerable technological opportunities, there are significant challenges in moving forward with clean energy technology. These challenges arise from the sheer size and complexity of existing systems, the degree to which these systems are embedded in our economy, and the high public expectations of safety and reliability they must meet. Energy systems traditionally have evolved incrementally.

• Third, these challenges can be met only by building on the collaborative strengths that our ecosystem has already demonstrated. Clean energy innovation depends on a national commitment to technological research; private-sector efforts to develop, apply, and commercialize products incorporating that research; and public policy.
In this report we convey the need for a comprehensive approach involving both public and private sectors in order to expand the current landscape of clean energy innovation and accelerate its processes. We hope that our report contributes to an understanding of the challenges presented and the approaches needed to address those challenges effectively. There is no final word on the subject. We see this report as a contribution to a continuing national dialogue and hope that it will stimulate further discussion, understanding, and action.

We are grateful for the opportunity that Breakthrough Energy and its partners have provided to explore this topic and recognize their commitment to advancing a meaningful and timely national dialogue. We hope that our report informs an appreciation of the complexity, reach, inherent dynamism, and promise of the U.S. clean energy innovation landscape and of the leadership that the United States can continue to provide.

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Executive Summary

The United States has been at the forefront of energy innovation for many decades. One of the most important reasons is the unique and extensive collaboration along the entire chain of innovation, from basic research to deployment, that engages the federal government, national labs and research institutes, universities, private sector, and state and local governments. This system has given the U.S. a global advantage for many decades.

The increasing focus on clean energy technology solutions and the potential for disruptive changes in energy systems points to the need for an objective review of the current clean energy innovation ecosystem. How does the clean energy innovation system work? What are its strengths and weaknesses? Is it up to the challenges? And how can it be improved and accelerated?

These are the questions that this study seeks to answer. Significant opportunities for clean energy innovation are presented by the changing U.S. energy supply profile; by advances in platform technologies such as digitalization and big data analytics; by expansion of electrification in the transportation and industrial sectors of the U.S. economy and the resulting electricity dependence of these sectors; by increases in urbanization and the emergence of smart cities; and by broad social and economic forces pushing to decarbonize energy systems in response to the risks posed by global warming and associated climate change.

Clean energy innovation supports multiple national goals: economic competitiveness, environmental responsibility, energy security, and national security. In serving these goals the need to address climate change is the challenge that calls most urgently for accelerating the pace of clean energy innovation.

Key features of energy systems, however, impede accelerated innovation. Energy is a highly capitalized commodity business, with complex supply chains and established customer bases, providing essential services at all levels of society. These features lead to systems with considerable inertia, focus on reliability and safety, aversion to risk, extensive regulation, and complex politics. Existing innovation processes face challenges as they work within these boundary conditions. The rapid pace of international energy investment, the commitments of most countries to Paris climate goals, and the ability of some countries such as China to rapidly increase clean energy investments challenge the preeminent position of the U.S. in clean energy innovation.

Successful clean energy innovation on a large scale in the U.S. requires alignment of key players, policies, and programs among the private sector, the federal government, and state and local governments. This report considers
these alignment needs through an assessment of the roles of these various groups. It also identifies critical clean energy technologies. It further suggests the value of regional efforts to advance innovation, and discusses ways in which federal tax policy could accelerate innovation. The report offers recommendations in each of these areas.

**The Role of the Private Sector**

The private sector is central to clean energy innovation, providing entrepreneurial vision, channeling financial resources, and connecting innovation to the rest of the energy system and the economy. At the same time, fundamental dynamics of the energy sector present significant challenges to clean energy innovation, stemming from basic industry characteristics and from the difficulty of capturing the full value of clean energy through market transactions alone. Innovators in clean energy face significant challenges in securing financial support and in demonstrating the compatibility of new technologies with existing systems. Over the past several years, venture capital has reduced its engagement in clean energy innovation, and traditional energy companies are exploring new models and mechanisms for innovation and investment.

While the initial stages of clean energy innovation are supported by a diverse, world-class set of U.S. research institutions, the innovation support system weakens as inventions move toward commercialization. The clean energy incubators that have emerged in recent years have so far tended to support software solutions. The availability of testing facilities for product demonstration is limited by the small number of facilities suitable for sustained testing and by their specialization.

Because of the energy system’s long cycles of adoption, a broad range of approaches should be deployed to make it easier for adopters to understand, anticipate, and support the innovations that are being generated at the early stages of the innovation process. These efforts include, on the part of energy companies, open innovation, standardization of procurement requirements, encouragement of innovation testing either through dedicated evaluation staffs or through performance metrics, and active outreach to become familiar with innovations at the development stage or earlier. They include, on the part of innovators, early attention to the needs of adopters as indicated by expressed needs and by the past performance of innovation efforts.

Investments are needed from foundations and from federal, state, and local governments to expand the availability of open-access testbeds and strengthen the effectiveness of incubators in accelerating commercialization of innovative technologies. Some of these investments could fund research into best practices and performance results of incubators and testbeds and of state and local programs supporting innovation.

Because clean energy innovation incentivizes only modest financial investments at precommercial stages, and because strategic corporate investment is focused primarily on those innovations recognized as useful to business objectives, strategic philanthropic investors and coalitions of industry investors with long-term horizons could play an important role in identifying and supporting promising technology ventures that are otherwise not commercially viable in the near term.
**Recommendations for Near-Term Actions**

- Adopters of new technology, such as utilities, should consider a variety of approaches to support the innovations that are being generated at the early stages of the innovation process, including: open innovation; standardization of procurement specifications; encouragement of innovation testing (either though dedicated evaluation staffs or through performance metrics); and active outreach to become familiar with innovations at the development stage or earlier.

- Strategic philanthropic investors and coalitions of industry investors with long-term horizons should play an active role in identifying and supporting promising technology ventures that are otherwise not commercially viable in the near term.

- Foundations, as well as federal, state, and local governments, should make investments to expand the availability of open-access testbeds and incubators to accelerate commercialization of innovative technologies (e.g. Cyclotron Road).

**Technologies with Breakthrough Potential**

A shared agenda of primary technology objectives can help ensure that programs pursued by multiple stakeholders in the clean energy space are timely, durable, and mutually supportive. It can give entrepreneurs and creative innovators a framework for assessing the prospects of a particular area of initiative and the steps needed to sustain critical innovations over long time spans, and it can give corporate adopters, financial investors, and policymakers visibility into the evolving future of clean energy.

A four-step methodology is suggested for identifying breakthrough technologies to address national and global challenges and help meet near, mid- and long-term clean energy needs and goals. These steps consider technical merit, potential market viability, compatibility with other elements of the energy system, and consumer value. Application of these considerations to a list of 23 potential technology candidates yields a key technology shortlist:

- **Storage and battery technologies**
- **Advanced nuclear reactors**
- **Technology applications for industry and buildings as sectors that are difficult to decarbonize**
  - Hydrogen
  - Advanced manufacturing technologies
  - Building energy technologies
- **Systems: electric grid modernization and smart cities**
- **Deep decarbonization/large-scale carbon management**
  - Carbon capture, use, and storage at scale
  - Sunlight to fuels
  - Biological sequestration
Recommendations for Near-Term Actions

• Federal investments in energy research, development, demonstration, and deployment (RDD&D) should be planned within a portfolio structure that supports potential breakthrough technologies at various timescales. There should be special focus on a critical subset of those technologies deemed to have very high breakthrough potential.

• Federal energy RDD&D portfolio investments should adopt a formal set of major evaluation criteria—such as technical merit, market viability, compatibility, and consumer value—with specific metrics for each criterion. These criteria should be used to prioritize programming and budget allocation decisions, as well as to develop public-private partnerships.

• Public and private sector stakeholders should collaborate in planning for and piloting of emerging technologies. A key component of these efforts is systems-level development plans that delineate technical challenges and risks; R&D pathways; cost and schedule assumptions; institutional roles (including public-private partnership opportunities); pathways to commercialization and diffusion; economic benefits; and consumer value.

• The Department of Energy (DOE) should lead a national effort to update the Basic Research Needs Assessments, originally initiated in 2001, to inform the assessments of emerging technologies with breakthrough potential, as well as the development of system-level roadmaps.

The Federal Government Role

The Federal government has long played a central role in supporting energy innovation. Through research grants, loan programs, tax incentives, laboratory facilities, pilot programs, and public-private partnerships, it has set the direction and pace of energy R&D, with profound impact on the national economy.

The principal agency funding clean energy innovation is the Department of Energy (DOE), which administers about 75 percent of all Federal energy R&D spending. DOE performs its role in partnership with its 17 national laboratories, academia, states, regions, other agencies, and the private sector. There are, however, several other Federal agencies with significant clean energy innovation budgets, including: the Department of Defense (DOD), the Department of Transportation (DOT), and the Department of Agriculture (USDA). Portfolios at these agencies are mission-focused, however, as opposed to being broadly based across all energy sectors.

As the primary Federal funder of energy R&D, DOE has played a critical role in changing the U.S. energy landscape over several decades. Shortly after its establishment in 1977, DOE characterized U.S. shale basins and supported the development of key drilling technologies that enabled horizontal drilling. It has had an ongoing and central role in developing supercomputing, an enabling technology for digitalization, artificial intelligence, smart systems, and subsurface characterization. Its investment in phasors and sensors support the smart grid. The Advanced Research Projects Agency — Energy (ARPA-E) — a DOE program —
has led to the creation of dozens of clean energy start-up companies which have raised more than $2.6 billion in private-sector follow-on funding.

However, DOE’s performance in advancing clean energy innovation would benefit from several institutional modifications. For example, the fuels-based organizational structure of the DOE, which has been in existence since 1979, is not optimized for modern energy systems and needs. It tends to lead to budget allocations by fuel, rather than prioritization by innovation potential.

The lack of long-term stable and predictable funding is also a concern for future R&D efforts at DOE. Although the Federal clean energy RD&D portfolio is significant (approximately $6.4 billion in FY 2016 if expenditures by all Federal agencies and by DOE on basic science research are included), some prominent government and industry leaders have recommended the need for funding levels at two to three times the current levels based on the energy industry’s current value to the economy (roughly $1.37 trillion). While the Bipartisan Budget Act of 2018 (BBA) set new caps for discretionary spending that are as much as 25 percent higher than the Administration’s budget — providing considerable headroom for near-term increases in spending for clean energy innovation — this agreement extends through FY 2019 only. The highly uncertain budget outlook for FY 2020 makes it difficult to plan an effective energy innovation portfolio focused on technologies with high breakthrough potential.

Recommendations for Near-Term Actions

- Congress and the Administration should initiate efforts to reorganize the Federal energy RD&D portfolio and the Department of Energy toward a fuel- and technology-neutral structure that (1) aligns with the highest priority opportunities, (2) enables systems-level integration, and (3) avoids gaps in crosscutting programs.

- Congress and the Administration should consider dedicated funding sources for energy innovation as a means to ensure predictable and increasing levels of clean energy RD&D funding based on international and cross-sectoral benchmarks.

- Federal policymakers should expand demonstration projects for key breakthrough technologies, while ensuring accountability via stage-gated project management, risk-based cost sharing, and assignment of demonstration project oversight to a single office within DOE.

- DOE and other agencies, as appropriate, should increase collaboration with the private sector and academia, including:
  - Instituting a multi-year and multi-agency portfolio planning process with broad-based stakeholder involvement from the private sector and academia.
  - Expanding use of prize authority to foster competition and open innovation.
  - Simplifying public-private partnerships with flexible financial vehicles like Technology Investment Agreements.
The Role of State, Local and Tribal Governments

State and city governments have regulatory authority over most of the myriad consumer, commercial, and industrial activities that collectively shape the country’s patterns of energy use. They play central roles in advancing clean energy innovation, above all by creating markets for the application of clean energy technologies and encouraging diffusion of those technologies through supportive financial mechanisms.

Cities are crucial clean energy innovation testbeds. Urbanization trends make "smart cities" especially important as technology platforms for a clean energy future. Enhanced federal-state-city, public-private, and private-private partnerships can help unleash smart city innovation for tailored urban services, mobility, and standard-of-living improvements in the 21st century. "Smart" improvements could also provide significant value to rural communities by enabling decentralized generation and manufacturing, improving energy efficiency, and supporting economic development.

The contribution of state, local, and tribal governments to clean energy innovation could be further strengthened by development of program best practices and standardization, capacity and resource enhancement, increased funding, and modernization of ratemaking and business models. Programs that support and promote clean energy and energy innovation require significant state and local administrative resources and expertise; offices and officials that run them often have limited resources. Also, traditional ratemaking policies and methodologies at the state and local level can act as barriers to deployment of innovative energy technologies due to their reliance on proven track records associated with reliability and cost savings.

Recommendations for Near-Term Actions

- States should consider adopting technology-neutral clean energy portfolio standards and zero-emissions credits in order to strengthen markets for clean energy innovation — to include renewables and other forms of zero or low-carbon energy.

- State and local regulatory agencies should consider new ways in which existing ratemaking principles could be adapted to incentivize utilities to deploy established clean energy technologies, test emerging energy technologies, and realize value from behind the meter technologies.

- States should collaborate to identify best practices in the deployment of clean energy technologies, including financing mechanisms, consumer protections and equitable sharing of benefits among all socio-economic groups and geographic locations.
The Role of Regional Clean Energy Innovation Ecosystems

Many of the innovation opportunities and risks faced by the energy sector are highly regional in nature and are appropriately managed by strategies tailored to each region’s specific needs. Strong regional relationships, for example, are observable among innovation, job creation, and technology deployment in the solar and wind energy industries.

Many energy innovation clusters in the U.S. are in the process of evolving into fully integrated innovation ecosystems. While federally funded RDD&D historically has not been well connected to state and regional economic development, activating these regional clusters to break down the barriers among federal, state, and local resources will create new synergies. National labs could serve as anchors for these efforts. While Federal support is important, regional leadership is critical. State and local governments, the private sector, universities, and philanthropies all have important roles in developing the particular strengths and shaping the particular contributions of regional innovation ecosystems.

Recommendations for Near-Term Actions

• Universities, private industry, philanthropies, state and local governments, and DOE should seek to expand and strengthen incubator capabilities within regional clusters to provide additional tools to enable innovators to conduct R&D and prototyping.

• DOE national laboratories, other federal laboratories, and Federally Funded Research Centers (FFRCs) can serve as anchors for regional clean energy innovation — and should be given sufficient flexibility in the expenditure of discretionary funds to support regional clean energy innovation options.

Mobilizing Increased Private Sector Investment in Energy Innovation

For U.S.-based entities, budget caps, reduced discretionary spending, and the Tax Cuts and Jobs Act (TCJA) will put downward pressure on Federal spending but will incentivize corporations to increase significantly business investments over the next decade (with estimates of up to $1.5 trillion in incremental new investment, some of which could be targeted to energy innovation and infrastructure. Attracting these funds into clean energy innovation will depend on success in aligning the various elements of the innovation ecosystem discussed in this report: public policies that encourage a robust pipeline of research and that create markets for clean energy applications, combined with private-sector institutions that facilitate the commercialization of innovations.

The TCJA left unchanged the existing tax credits for renewable energy (wind, solar and geothermal), but did not extend the so-called “orphan” tax credits for fuel cells, combined heat and power projects, geothermal heat pumps, and new nuclear power plants. Most of these credits had expired at the end of 2016. The Bipartisan Budget
Act of 2018 (BBA), passed in February, modified and extended the nuclear power PTC; other credits were extended only through 2017 and their fate is uncertain.

In addition, the BBA included expanded provisions for carbon dioxide (CO₂) capture, utilization and storage (CCUS). The new 45Q provisions have the potential to significantly enhance the development and market diffusion of CCUS technologies and processes in both industrial and power applications, creating commercial opportunities both in the U.S. and abroad. The provisions provide greater market and financing certainty to help attract additional follow-on investment from the private sector.

### Recommendations for Near-Term Actions

- DOE should set aside a small portion of its existing applied energy RDD&D funding to support accelerated de-risking of near-commercial innovative energy technologies and systems on an accelerated basis, to make these options more attractive for private capital investment.

- The new Section 45Q provisions expanding tax credits for carbon dioxide (CO₂) capture, utilization, and storage (CCUS) have the potential to significantly enhance the development and market diffusion of CCUS technologies and processes in both industrial and power applications, creating commercial opportunities both in the U.S. and abroad. Congress should consider additional measures to facilitate and accelerate CCUS deployment, including addressing uncertainties regarding long-term post-injection carbon management, monitoring, reporting and verification.