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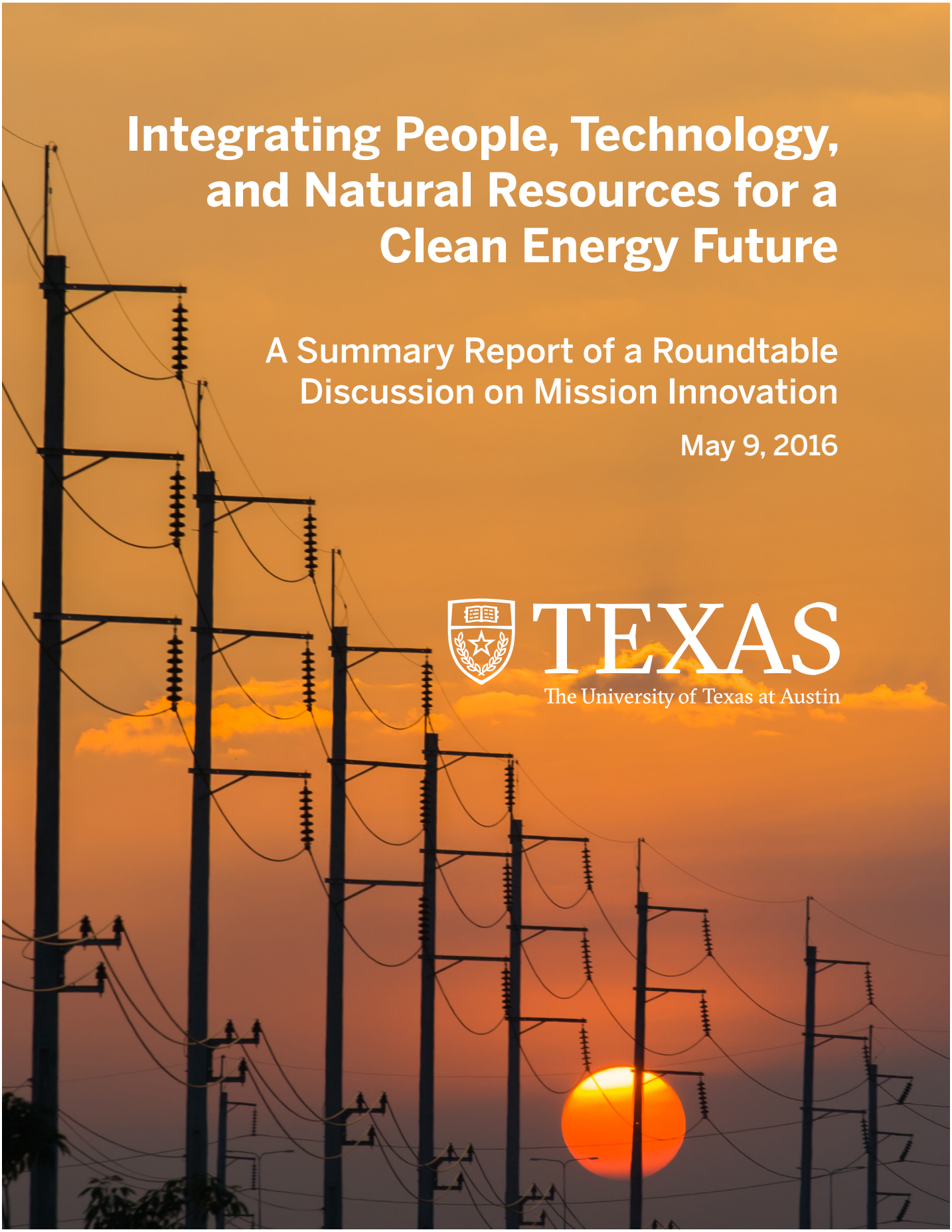
Integrating People, Technology, and Natural Resources for a Clean Energy Future:

A Summary Report of a Roundtable Discussion on Mission Innovation

Austin, Texas • May 9, 2016



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Host: Dr. Dan Jaffe, Vice President for Research, UT Austin

Moderator: Dr. Dale Klein, Associate Vice Chancellor for Research, UT System

Organizers: Dr. Scott Tinker, Director, Bureau of Economic Geology, UT Austin
Dr. Michael E. Webber, Deputy Director, Energy Institute, UT Austin

Rapporteurs: Dr. Todd Davidson, Research Associate, Energy Institute, UT Austin
Ms. Margaret Cook, PhD Candidate, Civil Engineering, UT Austin

Introduction and Overview

On May 9, 2016, the University of Texas at Austin hosted the Honorable Secretary of Energy Ernest Moniz, other U.S. Department of Energy officials, and stakeholders from industry and academia for an open, roundtable discussion about how regional implementation can be a vehicle to help the U.S. Department of Energy fulfill its *Mission Innovation* commitments for increased investments in research and development (R&D) with the goal of cost reductions for clean energy. This discussion was motivated by the desire to explore the ways by which regional public-private partnerships can be leveraged to achieve significant advances towards a cleaner, more resilient, secure, reliable, and affordable energy future.

Several contextual motivations were shared by Secretary Moniz as a way to initiate the discussion:

1. the clean energy goals identified by the *Mission Innovation* commitments (namely to reduce the costs of clean energy) will need increasing ambition over time,
2. the future low-carbon solutions will look very different in each region because of varying resources, interests, culture, attitudes, and capabilities, and
3. the intersections of energy and water will become increasingly important, raising the need for integrated management of resources and enabling infrastructures.

The invited participants represented a cross-section of industry, academia, and government. Within the industrial invitees, a mix of representatives attended from large companies and smaller, high-growth startups emerging in this space. The conversation took place over 2.5 hours with wide participation among the discussants and active engagement from Secretary Moniz. Several areas of excellence were identified for the south by southwest region of the United States (SXSWUS). The areas of regional excellence that received the most discussion were: 1) oil and gas, 2) clean energy entrepreneurship, and 3) integrated energy-water management.

Background information, themes, and outcomes from the discussion are organized and summarized below.

Mission Innovation & Breakthrough Energy Coalition

On November 30, 2015, world leaders gathered at the United Nations Climate Change Conference in Paris. In addition to establishing the *Paris Agreement* to address climate change, 20 of the attending countries launched *Mission Innovation,*[1] an effort to dramatically increase public and private innovation to develop the next generation of clean energy solutions. To accomplish the goal of advancing technological solutions, the 20 participating countries have committed to doubling their investment in clean energy research and development (R&D) over the next five years. In February of 2016, President Obama laid out his proposal to achieve the goal of doubling funding for these clean energy investments by increasing the United States commitment of "$6.4 billion in FY 2016 to $12.8 billion in FY 2021."[2]

The participating countries include some of the largest economies in the world – Canada, Mexico, Saudi Arabia, and the United States – as well as emerging economies. The 20 countries represent over 80 percent of global R&D funding for clean energy technology.[2] Furthermore, these countries represent a diverse array of interest in conventional, unconventional, and renewable energy resources.

The *Breakthrough Energy Coalition*[3] was also launched at the same meeting that initiated *Mission Innovation*. The *Breakthrough Energy Coalition* is an independent initiative led by Bill Gates that has organized 28 highly influential investors from around the world to commit to long-term investments that encourage development of new clean energy solutions. The coalition is driven by the idea that the private sector knows how to build companies and bring innovative ideas to the marketplace but that the current risk-reward for investing in unproven energy technologies is not aligned with the financial requirements of traditional sources of funding.

> "The existing system of basic research, clean energy investment, regulatory framework, and subsidies fails to sufficiently mobilize investment in truly transformative energy solutions for the future. We can't wait for the system to change through normal cycles."
>
> —Breakthrough Energy Coalition

The goal of the coalition is to spur sufficient development of breakthrough technologies to the point that traditional market-driven forces can support additional development and commercialization of sustainable solutions.

The SXSWUS region has three areas of excellence

On May 9, 2016, energy leaders from Texas and New Mexico as well as the Department of Energy and National Laboratories met in Austin, Texas to discuss what the SXSWUS region of the United States is contributing to the energy space. Texas, Oklahoma, and New Mexico share similar challenges related to energy and water resources. Each state has a legacy of oil and gas operations and, due to sunny climate and high winds, opportunities to increase its solar and wind adoption. Each state also has water constraints due to long-term climatic conditions and nearer-term increasing populations that will increase water stress. In addition, the states have technology centers and hotbeds of innovation centered around national laboratories and universities that foster a vibrant entrepreneurial ecosystem, leading to significant startup activity. These conditions create an excellent testbed for building on the region's three areas of expertise: clean energy entrepreneurship, oil and gas production, and the integration of water and energy.

The invited guests spoke of energy technology achievements made possible owing to the presence of a healthy existing industry combined with a newer entrepreneurial ecosystem, which includes synergies in the energy and technology industries. The SXSWUS region has a history of effective collaboration between industry, government, and academia including the successful public-private partnerships of SEMATECH and MCC in Central Texas during the 1980s. Subsequently, Austin became a hub for clean energy entrepreneurship due in part to the Clean Energy Incubator within the Austin Technology Incubator at UT Austin and non-profit consortia such as Pecan Street, Inc. These entrepreneurial infrastructures help foster growth in alternative energy technologies such as wind and solar while also merging the efficiencies of information technology

[1] mission-innovation.net

[2] "Fact Sheet: President's Budget Proposal to Advance Mission Innovation", The White House, Office of the Press Secretary, February 6, 2016.

[3] www.breakthroughenergycoalition.com

to improve existing oil and gas operations and logistics within the SXSWUS region. For example, Texas-based DrillingInfo provides data and technology to promote oil and gas innovation. In its midcontinent operations, Schlumberger works to improve software to allow companies to decarbonize their operations, reduce demands for water and sand, and program logistics for trucking operations—reducing road damage and offsite emissions. In addition, Central Texas has examples of leading university-private partnerships, such as the Advanced Energy Consortium (AEC), which has invested over $50 million in research to date in over 30 universities. The Gulf Coast Carbon Center (GCCC) is a DOE-UT-industry collaborative that has invested well over $50 million to date to conduct some of the largest scale subsurface carbon sequestration experiments in the world. Other industrial-academic partnerships include the Center for Next Generation Photovoltaics, which includes several universities and corporate affiliates.

The region also has a long legacy of excellence in oil and gas production. Recently, breakthroughs in hydraulic fracturing and horizontal drilling that were initiated in Texas kicked off an oil and gas boom with global impacts. That boom was the consequence of industrial innovation; academic research funded by industry, governments, and foundations; and steady policy support from the U.S. Department of Energy and the State of Texas, exemplifying the positive impacts that can occur from public-private partnerships implemented regionally.

During the roundtable discussion it was noted that the energy-water nexus is particularly relevant in the SXSWUS region because of strained water supplies, active energy production, and population growth. The discussion identified the topic as one where the region could be used as a testbed to develop solutions and establish national leadership on how to use the energy sector to improve the water sector and vice versa. Solutions were identified such as creating regional wastewater gathering systems for oil and gas operations, using off-peak renewable electricity from wind or solar to desalinate water for communities, or implementing dry cooling technologies at new thermoelectric power plants to decrease the water intensity of electricity generation.

Filling the pipeline of innovation

It was noted that among the region's key strengths is a healthy innovation system, including Sandia and Los Alamos National Laboratories, as well as many research universities. These research institutions tackle a range of topics including oil and gas, carbon capture and sequestration, renewable energy, energy storage, biofuels, and the water-energy nexus. In addition, other research entities such as Southwest Research Institute in San Antonio, Texas[4] and Houston Advanced Research Center in the Woodlands, Texas[5] provide important insights into clean energy, power systems, oil and gas development, and environmental impacts. In addition, the presence of major NASA facilities in Texas opens the possibility of multi-agency cooperation on issues related to miniaturizing energy systems for space applications and remote sensing for water resource management. Consequently, the SXSWUS region has a steady supply of recent graduates and professionals active as innovators in the energy and water space.

Integrating technology, people, and resources results in more innovation

The importance of cooperation was affirmed throughout the discussion, and it was suggested that collaborative, regional projects could be made stronger through connections with the Department of Energy (DOE), National Laboratories and other existing nonprofits, private research centers, and industry collaborators. Public-private partnerships could make use of data and resources available to different organizations. For example, start-ups could leverage projects from DOE and scale them for efficiency. This focus on start-ups, in particular, could also garner bipartisan support at the congressional level. Similarly, we might improve our innovation across the nation by collaborating regionally, nationally, and internationally and ensure that technologies developed in the lab are commercialized to deliver clean energy solutions to the world.

Several different collaborative mechanisms were discussed in detail. Secretary Moniz described a framework for Regional Innovation Partnerships

[4] www.swri.org/4org/orghome.htm

[5] www.harcresearch.org

(RIPs) to manage regional energy research portfolios.[6] The RIPs would have a nonprofit portfolio manager that would oversee the public, industrial, academic, and nongovernmental organizations participating in the regional research effort. The Regional Innovation Partnerships would be funded through *Mission Innovation*, and DOE would provide soft-touch oversight of each regional manager.

The DOE is also developing new energy research centers including a desalination hub, slated for Fall 2017, manufacturing institutes, and a center for developing technology to use supercritical fluids in the power generation sector.

Academic programs such as the Solar Decathlon encourage collaboration between between domestic and international universities, industry, government, and non-profits to create projects that promote innovation and training for the next generation of energy-minded professionals. The University of Texas at Austin participated in the most recent Solar Decathlon with the Technical University of Munich (TUM), working collaboratively to build NexusHaus, an integrated water-energy-food project including aquaponics irrigated through recycled greywater and demand reduction ideas like Integrated Thermal Energy and Rainwater Storage (ITHERST) to shift air conditioning load off-peak to the early morning hours.[7] With their ideas and help from public and private partners, the students were able to integrate interdependent resources to leverage energy and water savings, yielding patent filings and commercial interest.

In addition to integrating people and resources, integrating datasets from public and private sources could result in better, more relevant research efforts. For example, comprehensive and accurate completions and production data from oil and gas operations could result in improved data on water use. We could improve our energy information coverage by also including data from Mexico.

With the immense amount of data and technology available, it might, and in some cases already has, become complicated for humans to make quick, optimal decisions. For example, at the grid level, with so many operators and users producing and demanding energy at once, it is extremely important that humans who are at the controls are enabled to make the proper decisions, particularly during moments when the grid is stressed. As systems become more complicated, it will be even more important for human operators to make the right decisions. How do we work together to support resiliency with human involvement? And where can we use information technology at a system level? Integrating people, resources, and data will be important for finding an appropriate solution.

Finally, working together with the public is important for ensuring research and development produces solutions that can work in practice. For example, research in demand-side response has shown its viability. However, it remains unclear how to create the right incentives for its widespread use.

Funding for energy research and development remains a challenge

Funding energy projects can be troublesome due to the technically challenging and capital intensive process of developing and commercializing next generation energy solutions. Those challenges present themselves across different energy intensive industries such as transportation, manufacturing, and power generation. These challenges could be exacerbated by changes in market conditions. For example, when the price of oil is high, industry invests in innovative, potentially risky technologies to reduce oil demand and increase oil supply. However, under a low-price scenario, investment in research and development budgets often shrink, so R&D support must come from other sources if steady project support is required. In the electric sector, the regulatory structure inhibits investment. Competitive power markets are often swifter at adopting new technologies. However, it was mentioned that regulated markets could offer unique benefits to large capital projects for low-carbon facilities such as nuclear plants or coal with carbon capture.

The DOE has developed multiple funding mechanisms to ensure developments in technology reach the marketplace. Loan programs have promoted utility-scale photovoltaic development for instance. However, fees on loans might be high. Including more banks in the program could result in funding more projects. The ARPA-E program has improved

[6] https://www.whitehouse.gov/the-press-office/2016/02/06/fact-sheet-presidents-budget-proposal-advance-mission-innovation

[7] www.nexushaus.com

energy technology development and integration into the marketplace by providing a funding source for high risk, transformative technologies. The DOE also established the Office of Technology Transitions and the Clean Energy Investment Center intended to catalyze private sector investment. One solution that enjoyed widespread support during the discussion was the idea of increasing R&D support through the proposed regional collaborations of *Mission Innovation*.

Photo credit: Michael Webber

Photo credit: J.B. Bird

Recommendations for possible regional projects

The discussion identified several unique opportunities, conclusions, and outcomes.

Innovation through regional partnerships

Overall, participants in the discussion endorsed the idea of using regional partnerships as a vehicle to achieve *Mission Innovation*'s goal for accelerating the development and deployment of clean energy technologies. To achieve this goal the program should promote collaboration between universities, national labs, and industry to realize the greatest value for the program's investments. Partnerships between the three sectors can help utilize unique resources and cut across party lines that can help deliver the greatest value to all constituents involved. The value of including large and small industry players should also be encouraged by the program. Startups and mid-sized companies are often the engines for job creation and innovation. But, large, established corporations are often the ones that have the ability to scale technologies and commercialize them in a competitive marketplace. Collaboration between all of these players is crucial for the success of *Mission Innovation*. An example of how this collaboration has been achieved in the past can be seen by looking at the economic growth of Austin, Texas since the 1980s, fostered partly by public-private partnerships such as SEMATECH and MCC, which brought together government, academia, and industry.

Fostering cross-border cooperation

With its close geographical connection to Mexico, the SXSWUS region is primed for improving our energy relationship with our neighbor country as the energy markets in Mexico shift. Leaders from government, industry, universities, and nonprofits from the SXSWUS region have already begun meeting with leaders from Mexico to discuss the trajectory of energy innovation. SXSWUS leaders can provide insight through their expertise in natural gas and crude oil infrastructure and on-shore and off-shore drilling production, technology, and logistics. Because of our shared climatic conditions and existing expertise, we can also provide insight into solar production and water management for energy extraction, and we will need to continue to adequately manage our shared water resources at the border given the potential for increased energy production in that area.

Increased support for regional transmission

The locations of the best wind and solar resources are often geographically distant from the primary load centers across the United States. Such is true within the SXSWUS region, as well. Expanding the nation's transmission infrastructure could enable expanded utilization of some of the best renewable resources across the country. The value of transmission infrastructure is illustrated with the Texas Competitive Renewable Energy Zone (CREZ) program that launched investment in transmission infrastructure to help bring more renewable energy into the power sector. Subsequently, significant expansions in new solar and wind capacity were achieved, This experience provides a useful test case that can inform national policy discussions grappling with similar challenges.

Addressing methane leakage

Natural gas has often been referred to as a "bridge fuel" for decreasing the carbon intensity of the United States' economy. Combustion of natural gas, which is predominately methane (CH_4), emits much less carbon dioxide compared to conventional coal fired power plants. And, with the discovery and industrial development of shale gas fields across the United States, the nation has significant resources for fueling cleaner combustion-based power plants for many decades to come. However, recent studies have found that nontrivial amounts of natural gas are leaking from production sites and the nation's infrastructure.[8] This finding is significant because methane has a global warming factor which is much more potent in the short-term than carbon dioxide (CO_2). As a result, the presence of leaks within our natural gas infrastructure has the potential to negate some of the environmental benefits of expanding our use of natural gas within the electricity sector.

[8] Allen, D. T., Torres, V. M., Thomas, J., Sullivan, D. W., Harrison, M., Hendler, A., ... & Lamb, B. K. (2013). Measurements of methane emissions at natural gas production sites in the United States. Proceedings of the National Academy of Sciences, 110(44), 17768-17773.

Dedicated effort is needed to improve our natural gas infrastructure and our processes for producing and handling the valuable hydrocarbon fuel. The SXSWUS region is uniquely suited to help address this issue due to the legacy of extensive oil and gas operations in the region as well as the substantial refining and manufacturing centers that handle large quantities of natural gas. In addition, the region has many researchers and innovative industrial actors who are experts on this topic and can use regional facilities as a testbed for implementing solutions.

Promote large-scale pilot studies

The SXSWUS region is uniquely suited to conduct large-scale pilot studies for emerging energy solutions. This region accounts for nearly 10% of national GDP[9], over 10% of CO_2 emissions[10], has large concentrated population and manufacturing centers, significant expanses of rural land, and the ERCOT grid resides almost entirely within the state of Texas. These characteristics allow the SXSWUS region to be an excellent test bed for studying the impact of emerging technologies before they are deployed nationwide. Several example projects are as follows:

CO_2 Management: As a region that pioneered the use of CO_2 for enhanced oil recovery, is the largest emitter of CO_2 in the nation, and has the most abundant installed capacity of CO_2 pipelines, the SXSWUS region is well poised to develop a low-carbon path for the nation through carbon capture and sequestration. Large scale research programs are already underway along the gulf coast, and large-scale industrial activity is in place in west Texas oil fields. As carbon management grows as a priority, regional innovation will be critical for developing new solutions.

Deep Decarbonization of Transportation: Of all the sectors, transportation is particularly difficult to decarbonize. Electrification or proxies for electrification (such as electrically-produced hydrogen) are identified as one promising pathway. With an abundance of low-carbon solar and wind resources, the region makes an interesting test case for electrifying and decarbonizing transportation. New fuels along with new business models such as mobility services could lead to large-scale changes. With its mix of large rural areas and economically vibrant cities, the region is an interesting combination of transportation challenges.

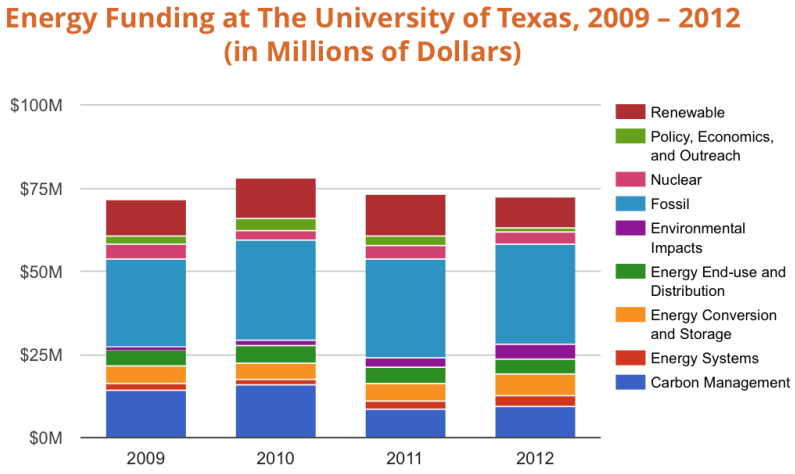
Creating a Hydrogen Infrastructure: The benefits and challenges of hydrogen are reflected in the current DOE effort underway called *H2 @ Scale*. Texas is uniquely qualified to study the impact of a hydrogen economy due to the exceptional domain knowledge in the state and the fact that the vast majority of existing hydrogen infrastructure lies along the Texas coastline to support industrial customers. Hydrogen could solve multiple problems—such as using variable wind and solar for its production, which firms up grid reliability and reduces emissions while serving multiple customers, such as steel mills, refineries, and transportation hubs. Consequently, if large-scale deployment of hydrogen doesn't work economically in Texas, it likely will not work anywhere else in the world.

[9] www.bea.gov/regional/index.htm

[10] www.eia.gov/environment/emissions/state

Overview of energy research at the University of Texas at Austin

The University of Texas at Austin attracts more than $70 million in funding to conduct cutting-edge energy research in more than two dozen academic units and research centers. UT Austin scientists, engineers and other researchers are engaged in basic and applied research across a broad array of topics. These experts work closely with industry, government, and non-profit organizations to improve the delivery and transformation of energy. Funding of research projects at UT Austin comes from a variety of sources, including government agencies such as the Department of Energy and the National Science Foundation, energy companies, private donors, and NGOs.



An updated inventory of research funding is available via the Energy Institute at UT Austin: energy.utexas.edu/funding-chart. Approximately half of the research funding is for fossil fuels. The other half of research funding is to spur innovation and scientific advances for topics such as alternative fuels, energy storage, grid management, and reducing environmental impacts.

Attendees

Honorable Secretary of Energy Ernest Moniz, U.S. Department of Energy

Melanie Kenderdine, U.S. Department of Energy

Kimberly Rasar, U.S. Department of Energy

Doug Hollett, Principal Deputy Secretary Fossil Energy, U.S. Department of Energy

Alex Manfre, CEO, Braclet

Allen Gilmer, CEO, DrillingInfo

Amanda Dodd, Manager, Sandia National Labs

Ashok Belani, Executive Vice President Technology, Schlumberger Limited

Benny Freeman, Professor, Department of Chemical Engineering, UT Austin

Bert Haskell, CTO, Pecan Street, Inc.

Bridget Scanlon, Senior Research Scientist, Bureau of Economic Geology, UT Austin

Charlie Upshaw, PhD student and Solar Decathlon Team Captain, Department of Mechanical Engineering, UT Austin

Chris Cooper, CEO, Oilfield Water Logistics

Colin Meehan, Director of Regulatory and Public Affairs, First Solar

Dale Klein, Associate Vice Chancellor for Research, UT System

Hap Alper, Associate Professor, Department of Chemical Engineering, UT Austin

Joseph Kopser, Co-founder, National Security Incubator; CEO and Founder, RideScout

Juan Garcia, President & Co-founder, DISCO Learning Media

Kalthleen Baireuther, Senior Program Coordinator, Austin Technology Incubator/ ATI Clean Energy Incubator, UT Austin

Keith Cole, CEO, WaterLens

Keith Johnston, Professor, Department of Chemical Engineering, UT Austin

Lee Ann Kahlor, Associate Professor, Moody College of Communication, UT Austin

Maura Yates, MP2 Energy, Vice-President of Risk Management

Michael Legatt, CEO and Founder, Resilient Grid

Michael Webber, Deputy Director, UT Energy Institute; Associate Professor, Department of Mechanical Engineering, UT Austin

Mitch Jacobson, Director, Austin Technology Incubator/Clean Energy Incubator, UT Austin

Mukul Sharma, Professor, Department of Petroleum and Geosystems Engineering, UT Austin

Scott Tinker, Director, Professor, Bureau of Economic Geology, UT Austin

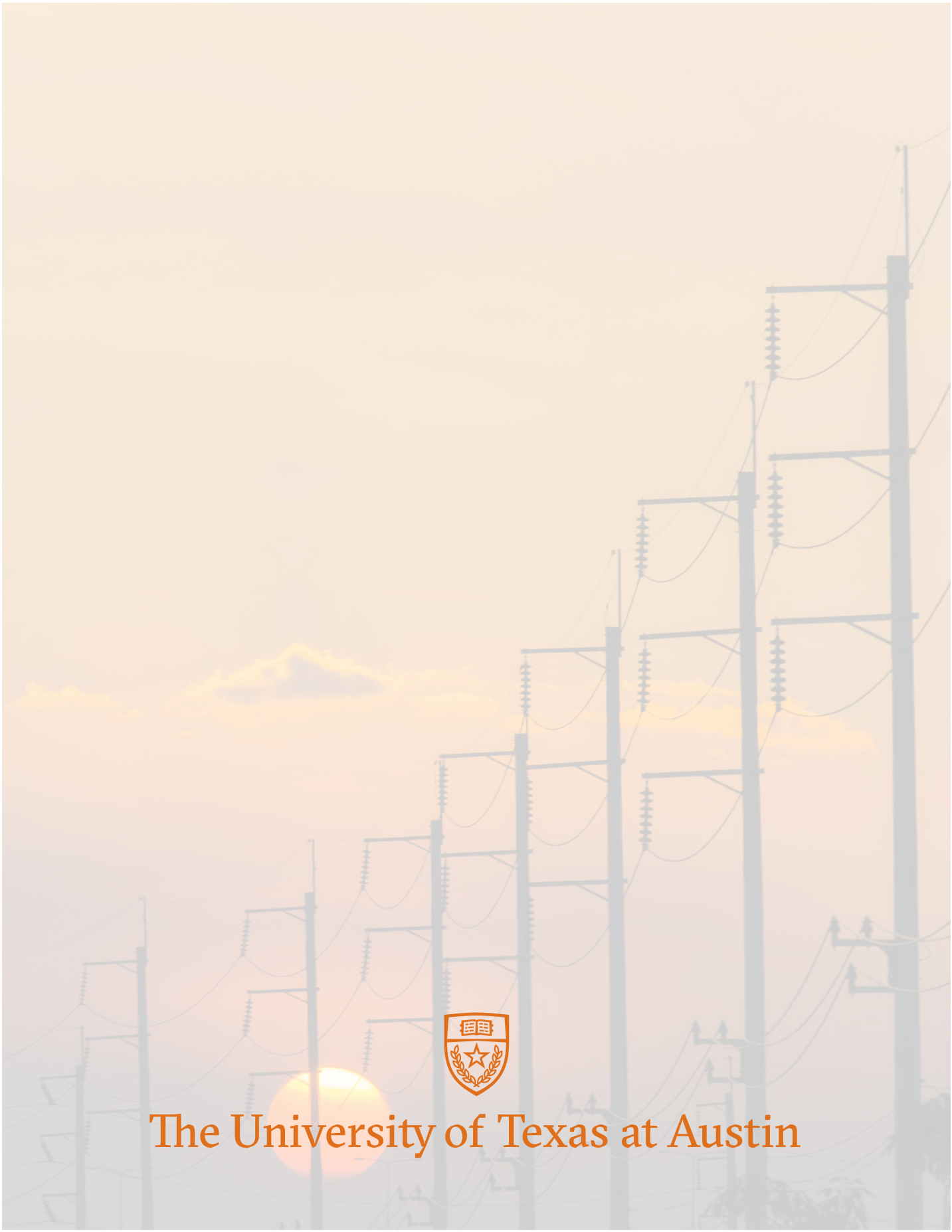
Sheila Olmstead, Associate Professor, Lyndon B. Johnson School of Public Affairs

Tip Meckel, Research Scientist, Bureau of Economic Geology, UT Austin

Tom Juenger, Professor, Department of Integrative Biology, UT Austin

Vaibhav Bahadur, Assistant Professor, Department of Mechanical Engineering, UT Austin

Warren Sumner, President, Orion Water Treatment Solutions



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