



University of Colorado Boulder

*North Central/Inter-Mountain West
Regional Clean Energy Innovation Summit*

Boulder Colorado • September 19, 2016

North Central/Inter-Mountain West

Regional Clean Energy Innovation Summit Report

Sept. 19, 2016 Summit Hosted By



Colorado Energy Research Collaboratory
Partners for Clean Energy



Colorado State University



COLORADO SCHOOL OF MINES
EARTH • ENERGY • ENVIRONMENT



University of Colorado Boulder



NATIONAL RENEWABLE ENERGY LABORATORY

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Colorado Energy Research Collaboratory

Partners for Clean Energy

Introduction

This report summarizes results from a regional clean energy innovation summit convened by the Colorado Energy Research Collaboratory ("The Collaboratory") on September 19, 2016 in Boulder, CO. The purpose of the summit was to begin the process of developing a U.S. North Central and Intermountain West regional approach to clean energy innovation that:

- minimizes resource conflicts and environmental impacts, and
- maximizes participation, collaboration, and economic impact.

Once initiated, the regional initiative envisioned would support the broader "Mission Innovation" initiative announced by President Obama and other global leaders in Paris, France in 2015.

The summit convened 167 individuals in person and approximately 30 on the live stream over a ten-state region (ND, SD, NE, KS, MT, ID, UT, CO, WY, NM) to acquire input and ideas from a wide variety of participants on topics including regional energy and innovation ecosystem strengths, opportunities and challenges; opportunities for regional public/private partnerships leading to pilot-scale commercial deployment; and understanding how public policy decisions influence achieving these goals.

Rationale

Both nationally and internationally, organizations in the business of energy production, distribution and end-use are facing uncertainty, but there is general consensus that decarbonization will be a part of our energy future. Thus, federal, regional, state and local stakeholders must find a balance between technologies, policies, market forces, and the financing mechanisms that enable a decarbonized future. On the federal level, the Obama Administration has used executive power to enact emissions reduction policies. Likewise, several states and local entities have adopted policies and programs to curb carbon emissions. Between these ends of the stakeholder spectrum reside multistate regions - each with a unique set of energy and carbon assets, issues and opportunities. Thus, a core reason to convene stakeholders in the North Central and Intermountain West regions of the U.S. was to consider unique issues, opportunities, and challenges for clean energy innovation in the region.

A large portion of the U.S. fossil and renewable energy resources reside in our region. The region has a low population density, extensive agriculture resources, large federal and tribal land footprints, and faces significant water challenges. In addition, other factors related to ecosystems, public policy, technoeconomics, and human factors must be addressed as the region develops and implements a clean energy technology innovation strategy (see Figure 1).

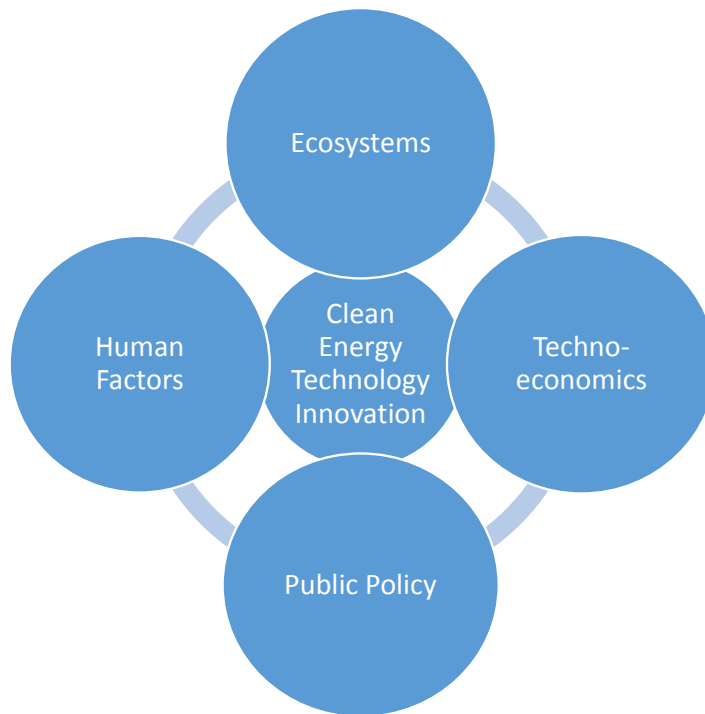


Figure 1. Clean Energy Technology Innovation in the U.S. North Central and Intermountain West

With that said, companies of all sizes are already working on decarbonization strategies in the region. Coupling this with an expansive clean energy innovation network that includes multiple national laboratories and research universities in every state, the North Central and Intermountain West region is poised to lead several aspects of the nation’s clean energy revolution.

For these reasons, the region seeks to leverage U.S. Department of Energy Mission Innovation resources - summarized in Appendix A - to help make progress toward deep decarbonization. This, in turn, will decrease uncertainty for utilities and other power providers and infuse new technology and other innovations that lead to widespread economic prosperity.

Summary and Conclusion

Conclusions based on the four definitive questions posed during the summit:

- 1. To facilitate today's activities, four topic areas have been proposed (Grid and Storage; Food/Energy/Water; Energy/Climate; Renewable Sources). These are not meant to be exclusive of the regional needs. Are there additional focus areas that should be added to the list?**

Outcome: The region is rich in conventional energy resources, renewable energy resources, research and intellectual capacity, and a robust energy industry. The general consensus is that these four topics proposed are relevant and vital for the region. However, additional items for further consideration may include the role of energy efficiency, geopolitical, social and behavioral issues.

- 2. What are the regional strengths and opportunities in the four proposed topic areas and any topic areas added? Is there an overarching theme for this region that should be pursued? If so, please summarize.**

Outcome: The region boasts four DOE national laboratories and dozens of other federal R&D facilities such as NOAA, NIST, USDA labs, extension agencies, etc. The unique characteristics of the region include a large land area requiring a different approach to power transmission than in the more densely populated areas on the East and West coasts. The large reserves of fossil energy provides the motivation for production with the lowest possible environmental impact, and emphasizes the long term needs for CO₂ capture, sequestration and/or reuse. The region has significant capacity for biofuels, particularly advanced biofuels, but is challenged with a relatively arid environment that is water constrained in many regions. Cultivation of biofuels/biomass is challenged by the latitude variation of the region extending from the Mexican to Canadian borders.

- 3. Commercial deployment of energy technologies is required to have impact at a large scale. What are the opportunities for industry and research communities in developing and deploying next generation energy innovations at a large scale in our region?**

Outcome: Industrial scale up of clean energy technologies in the region is challenged by regulatory uncertainty around market signals on CO₂ emissions as well as incentive programs for renewable energy or CO₂ capture, sequestration or reuse programs. The research institutions in the region can be harnessed to stimulate the development of next generation energy products, but industry access to research institutions need to be improved.

- 4. How can we align anticipated research topics with state policies that become key drivers of deployment?**

Outcome: Many of the states in the region have renewable portfolio standards, but these are primarily being fulfilled by build out of proven solar and wind technologies. The states could help to spur innovation by encouraging adoption of innovative new technologies for at least a portion of procurements to meet RPS goals.

The reports on the four breakout sessions in the Appendices contain many novel ideas around regional innovation. These comments were captured and represent the data that will ultimately be used to craft a regional plan. A number of themes were repeatedly identified by breakout groups and are summarized in the following sections.

Regional Overview

The proposed region, shown in Figure 2, includes North Dakota, South Dakota, Nebraska, Kansas, Colorado, Wyoming, Montana, Idaho, and Utah. Depending on the outcome of continued planning efforts, New Mexico may also be included in the region.

The initial nine-state region encompasses approximately one third of the continental United States land area and 824,853 square miles. It is home to major portions of the High Plains and Intermountain West. (Source: US Census Bureau).



Figure 2. North Central and Intermountain West region

Energy Resources

The region holds approximately 44% of the U.S. fossil energy reserves and accounts for roughly 25% of total annual U.S. energy production. Specifically, it supplies over 26% of the nation's crude oil, 47% of all coal production and 21% of natural gas production. The region is also home to 7% of the nation's refining capacity. Because of its production and refining capacity, the region's per capita energy use averages 468 million BTUs. The region is also a significant producer of renewable energy. The nine states combined account for roughly 14% of the U.S. renewable production.

A state-by-state energy resource summary is provided below. (Source: EIA)

Montana

The Williston Basin of Montana and North Dakota holds one of the largest accumulations of crude oil in the United States; its Bakken and Three Forks formations are estimated to be capable of producing 7.4 billion barrels of oil. Montana holds more than 25% of the nation's estimated recoverable coal reserves and is the seventh-largest coal-producing state. It produces close to 5% of U.S. coal and distributes coal to nine other states. Montana's four refineries, with almost 30% of U.S. Petroleum Administration for Defense District 4 (Colorado, Idaho, Montana, Utah, and Wyoming) refining capacity, are able to process heavy Canadian crude oil for regional markets. Wind electric power generation in Montana grew by 12% in 2014 and supplied 6.5% of the state's net electricity generation. Montana created a Renewable Energy Resource Standard requiring that public utilities and competitive electricity suppliers obtain 15% of electricity sales from renewable energy resources by 2015. The standard requires electricity suppliers to buy a set amount of power from smaller community-based renewable energy projects.

Idaho

Idaho is rich in renewable energy resources; the state's volcanic formations provide substantial geothermal energy potential. Over 80% of Idaho's net electricity generation comes from renewable energy resources, and Idaho had the fifth-lowest average electricity prices in the United States. Idaho's in-state net electricity generation accounts for approximately 65% of the state's total electric industry retail sales. The remainder comes from other states and international imports. Hydroelectric power supplies 60% of net electricity generation in Idaho, the second-largest share in the nation. Idaho's wind generation increased by 13% in 2014 and provides close to 20% of net electricity generation.

Utah

Utah produces nearly 2% of U.S. coal and ships 27% of that production out of state, of which nearly one-third was exported. Utah's five refineries process crude oil primarily from Utah, Colorado, Wyoming, and Canada; the UNEV pipeline, opened in late 2011, is the first to connect Utah's refineries to Las Vegas, the largest city in Nevada. Recently, for the first time, coal produced only three-fourths of Utah's net electricity generation and natural gas produced just under 20%. State planners expect the natural gas share to continue rising as older coal units are shut down. Utah has the 10th lowest average electricity prices in the nation and a voluntary goal of using cost-effective eligible renewable energy resources to provide 20% of its 2025 adjusted retail electric sales. Today, approximately 5% of net electricity generation comes from renewable resources.

Wyoming

Wyoming produces approximately 40% of all coal mined in the United States and 33 states receive coal from Wyoming mines, with 8 states, including Wyoming, obtaining more than 90% of their domestic coal from Wyoming. Wyoming accounts for approximately 7% of U.S.-marketed natural gas production and almost 88% of net electricity generation in Wyoming came from coal and about 12% came from renewable energy resources, primarily wind. Wyoming has the third-lowest average electricity price of any state.

Colorado

Colorado's vast fossil fuel resources include the Niobrara Shale, with resource estimates running as high as 2 billion barrels of oil. From 2004 to 2014, crude oil production in Colorado more than quadrupled; in the same period, marketed natural gas production rose 51%. In 2014, 60% of the electricity generated in Colorado came from coal, 22% from natural gas, and 18% from renewable energy resources. Colorado's Renewable Energy Standard requires investor-owned electric utilities to provide 30% of electricity sold from renewable energy sources by 2020, with 3% coming from distributed generation. In 2014, Colorado's grid-connected solar photovoltaic capacity of 430 megawatts was the ninth largest in the United States, and the state obtained nearly 10 times as much net generation from solar power as it did in 2009. Average household energy costs in Colorado (\$1,551 per year) are 23 percent less than the national average, primarily due to historically lower natural gas prices in the state.

North Dakota

North Dakota is the second-largest crude oil-producing state in the nation and accounts for over 12.5% of total U.S. crude oil production; a 251% increase in production from 2010 to 2014 was

primarily driven by horizontal drilling and hydraulic fracturing in the Bakken formation. North Dakota has 5.5% of the nation's recoverable coal reserves at producing mines; the state's coal production, which all comes from surface mines, accounts for approximately 3% of U.S. coal production. Although North Dakota's total energy consumption is among the lowest in the nation as a result of its small population, the state's consumption per capita ranks among the highest, in part because of the energy-intensive industrial sector and high heating demand in winter. Approximately 75% of North Dakota's net electricity generation comes from coal, almost 17.5% comes from wind energy, and about 7% comes from conventional hydroelectric power sources. North Dakota has abundant wind resources and ranks 6th in the nation in wind energy potential, 11th in utility-scale generation, and 11th in installed capacity.

South Dakota

South Dakota ranks sixth in the nation in ethanol production capacity and has more net electricity generated from hydroelectric power than from any other source. Wind and hydroelectric power provide about three-quarters of South Dakota's total net electricity generation. South Dakotans' price for electricity averages about 9 cents per kilowatt hour across all sectors, compared to the national average of close to 10.5 cents per kilowatt hour. The National Renewable Energy Laboratory estimates that about 94% of South Dakota's land area is suitable for wind resource development using current technology.

Nebraska

Nebraska ranks second in the nation, after Iowa, in corn-based ethanol production capacity and obtains about three-fifths of its net electricity generation from coal and about one-fourth from nuclear power. The National Renewable Energy Laboratory estimates that more than 90% of Nebraska has suitable conditions for commercial-scale wind-powered electricity generation. Nebraska is among the top 10 states in per capita energy consumption because of its energy-intensive industrial sector, led by food processing and chemical manufacturing. Farm irrigation is electricity-intensive and seasonal; it entails high costs for electricity that increase the average reported cost of electricity for Nebraska's industrial sector. Nebraska obtains more than 10% of its total net electricity generation from renewables, and wind supplies almost three-fourths of the renewable generation.

Kansas

Kansas ranks 10th in crude oil production among the 50 states, excluding the federal offshore areas. The Hugoton Gas Area, which contains one of the top-producing natural gas fields in the United States, is located in southwestern Kansas, as well as in parts of the Texas and Oklahoma panhandles. The Mid-Continent Center, located in south central Kansas, is a key natural gas supply hub that pipes production from several states in the region east to major consumption markets. Electric utilities in Kansas provide 80% of the state's net electricity generation; 57% of net electricity generation comes from coal-fired electric power plants. Approximately 20% of net electricity generation in Kansas comes from wind energy, making wind the state's second largest power provider, after coal.

Clean Energy Innovation Stakeholders

Regional stakeholders in the nine to ten state area include a wide range of public and private entities. From Fortune 500 companies to small businesses, the region boasts a plethora of for-profit companies involved in all aspects of renewable and fossil energy production; energy transmission, distribution, and storage; and energy end-use systems and technologies. The region also includes numerous research universities and USDOE national laboratories conducting extensive clean energy R&D (see Figure 3).

Relevant state energy contacts in each of the nine states are provided in Table 1 located in Appendix B. In addition to the above stakeholders, a number of local governments, federal agencies, nongovernmental organizations, and advocacy groups factor into the region's energy production distribution and end use.

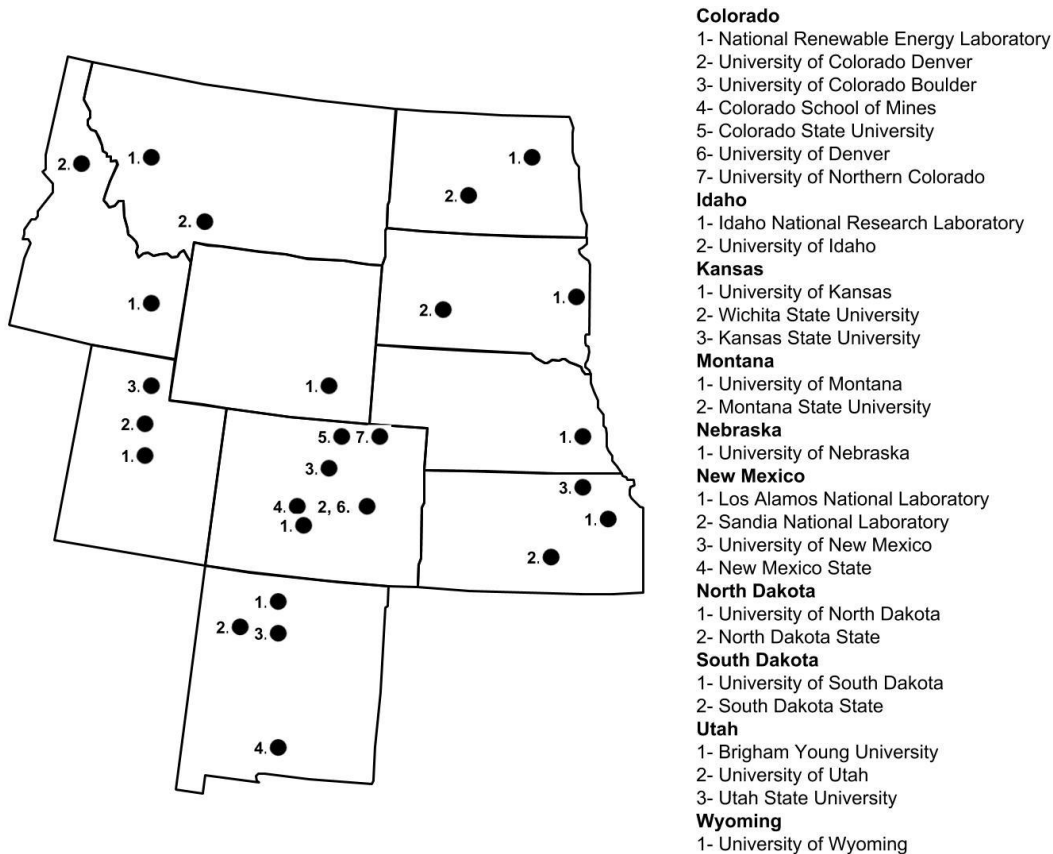


Figure 3: USDOE-identified research universities with highest and higher research activity per Carnegie Classification of Institutions of Higher Education (2015 update). Note that New Mexico is under discussion.

Summit Objectives and Focus Areas

The overarching goal of the regional clean energy innovation summit was to assemble relevant regional stakeholders to begin developing a region-wide approach to clean energy production, distribution, and end-use that minimizes resource conflicts and environmental impacts while maximizing collaboration, manufacturing capacity, and overall economic value in this half century. To achieve this goal, the Summit hosts identified four focus areas, illustrated below, which were the subject of the Summit's pre-summit conference calls and afternoon breakout sessions during the Summit.

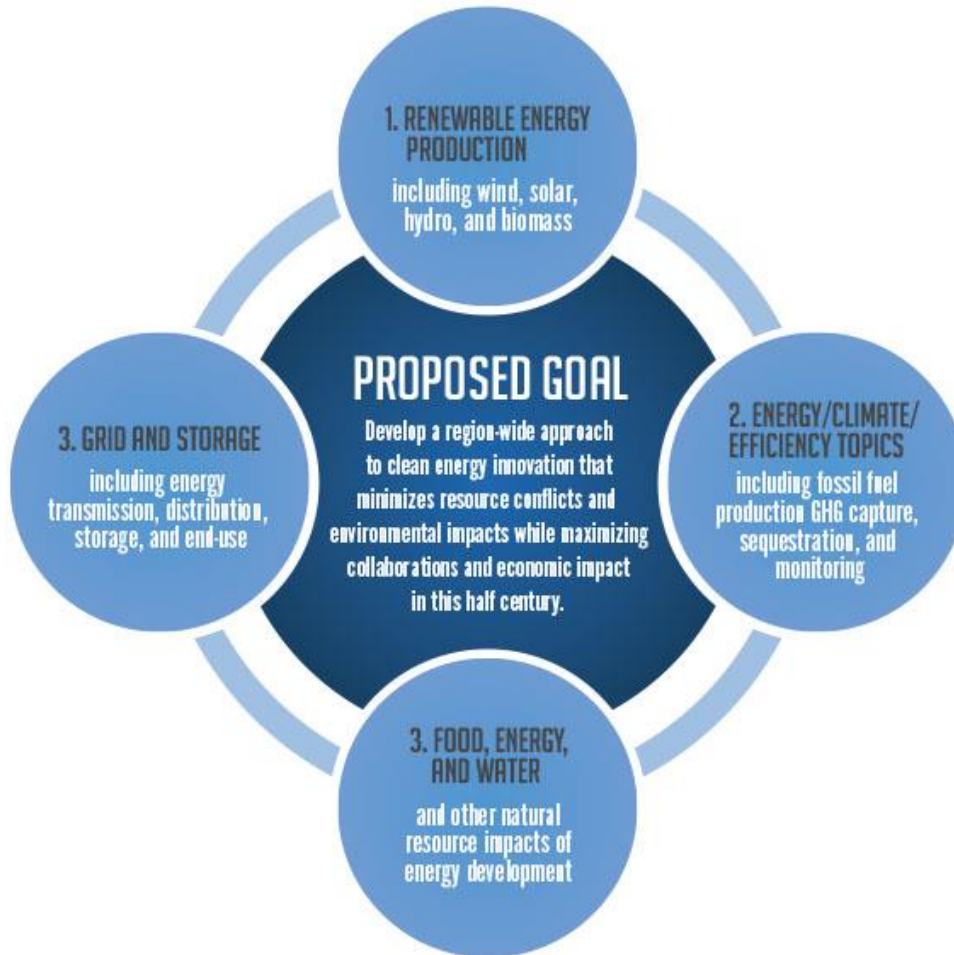


Figure 4. Goal of summit with four focus areas

Each focus area was chosen because of the need to: a) develop region-wide analytical models and decision support tools emphasizing systems approaches that identify, quantify, and solve resource conflicts and environmental impacts arising from competing clean energy innovation options; and b) research, develop, demonstrate, and deploy technologies leveraging our region's unique expertise, capabilities, resources, and related infrastructure.

Summit Organization and Outcomes

The Regional Clean Energy Innovation Summit was organized by the Colorado Energy Research Collaboratory (The Collaboratory). Since 2006, the Collaboratory has been a research partnership among the National Renewable Energy Laboratory and Colorado's premier research universities: Colorado State University, the University of Colorado Boulder, and the Colorado School of Mines.

Organizers of the Summit invited over 400 people from the ten state region (ND, SD, NE, KS, MT, WY, UT, ID, CO, NM) including research institutions, national labs, state energy offices, state economic development offices, and industry. The full agenda for the Summit is provided in Appendix C.

Prior to the Summit, four focus-area co-leaders were selected to develop an overview of the four topic areas (see Fig. 4) and host separate pre-summit one-hour conference calls on Sept 13 and 14. During the calls, numerous stakeholders provided input to the four breakout session topics (Grid and Storage; Food/Energy/Water; Energy/Climate/Efficiency; Renewable Energy Sources).

Nearly 200 people attended in person or watched the live-streamed sessions. After introductory and opening remarks from Dr. Peter Green (NREL) and former Colorado Governor Bill Ritter (CSU), respectively, a general panel session consisting of national and regional experts summarized the region's clean energy innovation needs, issues and opportunities & addressed fundamental questions including:

- What are the best ways to collaborate among power providers, utilities, national labs, universities, government entities, and finance organizations to ensure clean energy technology deployment in a timely way?
- How can we ensure research conducted at research universities, national labs, and in private industry is relevant to the decarbonization future?
- How must we address the business model and goals of utilities in the context of integrating new technologies such as distributed renewable generation and grid-scale storage?
- How do we achieve decarbonization goals without increasing costs for those who can't afford it? For example, coal miners in WY/CO.
- How do we justly transition sub-regional carbon-based economies in a way that ensures equity and economic opportunity?

The panel was made up of Martin Keller (Director, National Renewable Energy Laboratory), Mark Northam (Executive Director, School of Energy Resources, University of Wyoming), Robert Simm (Senior Vice President, MWH/Stantec) and Frank Prager (Vice President for Environmental Affairs, Xcel Energy). A summary of the topics covered in the general session can be found in Appendix D. The panel, moderated by Bill Ritter, discussed regional needs and opportunities.

In the afternoon, focus-area co-leaders led breakout discussions on their respective topics and summarized outcomes to all of the Summit's participants. In each of the four breakout sessions, participants:

- identified subtopics of interest,
- identified relevant regional strengths, opportunities, and crosscutting themes,
- inventoried applicable regional clean energy innovation assets,
- outlined potential research areas for further development along with potential next steps, and
- documented the overall session outcomes and observations, see Appendix E through H.

The Summit was concluded with a general session led by Dr. Alan Rudolph, Vice President for Research at Colorado State University, that summarized the outcomes of from the day's events (see Appendix I). All sessions were live streamed and are back up on the www.regionalsummit.org website for viewing.

APPENDIX A – Regional Partnerships

REGIONAL CLEAN ENERGY INNOVATION PARTNERSHIPS FY 2017 Congressional Budget Request

To accelerate clean energy innovation and commercialization in the U.S., the Department of Energy is establishing a new Crosscutting Innovation Initiative program in FY 2017. This program will fund research, development, and demonstration (RD&D) activities that will strengthen regional clean energy innovation ecosystems; accelerate next-generation clean energy technology pathways; and encourage clean energy innovation and commercialization collaborations between our National Laboratories and American entrepreneurs. As a part of this program, \$110 million is requested to support a new competition to establish up to 10 **Regional Clean Energy Innovation Partnerships (RCEIPs)** around the country, cost-shared with state, industry, academic, and other stakeholder partners.

The U.S. energy system is composed of regions with unique energy needs and opportunities. The goal of this subprogram is to accelerate the pace of innovation in clean energy technologies through the cost-shared, technology neutral partnerships that fund RD&D to address the clean energy challenges and opportunities specific to regional energy resources, policies, customer needs, markets and the innovation capabilities of various regions of the country.

A regional approach to innovation is responsive to the conclusion of The National Research Council 2012 Report, *Rising to the Challenge*, noting that “Historically, federally funded R&D has not been connected to state and regional industrial development. Bridging that gap can create the local talent and technology base needed to convert these U.S. investments into domestic companies, industries and jobs.” Regional Clean Energy Innovation Partnerships complement national level RD&D efforts.

Specific benefits of this approach include:

- Leveraging existing knowledge clusters and comparative strengths of a geographic region;
- Linking the needs of industry and energy decision-makers with technical resources and expertise at universities and laboratories to enhance clean energy technology commercialization, economic development, and manufacturing;
- Sharing risks and pooling resources between the public and private sector to conduct RD&D projects with sustained and predictable funding; and
- Allowing for the development of new pathways for RD&D involving nonfederal stakeholders and other performers not typically engaged through existing DOE programs.

In FY 2017, DOE will solicit and competitively select up to 10 Regional Partnerships that will:

- Competitively select RD&D projects for financial assistance based on technical merit and, generally, connecting innovators in their regions with RD&D funding;
- Provide analysis, data, access to federal RD&D facilities, and project management;
- Support development of early prototypes;
- Encourage and support collaborative RD&D, regional public-private partnerships, and consortia of innovative clean energy entities;
- Develop in collaboration with stakeholders regional energy innovation roadmaps to facilitate RD&D planning and inform annual plans submitted to DOE; and
- Coordinate with other Regional Partnerships on best practices and technology projects relevant to multiple regions.

APPENDIX B -- Stakeholders

STAKEHOLDER	MT	ID	UT	WY	CO	ND	SD	NE	KS	NM
GOVERNOR	Steve Bullock	Butch Otter	Gary Herbert	Matt Mead	John Hickenlooper	John Dalrymple	Dennis Daugaard	Pete Ricketts	Sam Brownback	Susana Martinez
ENERGY POC	Brad Johnson	Scott Pugrud	Laura Nelson	Alan Minier	Jeff Ackermann	Julie Fedorchak	Chris Nelson	David Bracht	Jay Scott Emler	Tony Delfin
ECON. DEV. POC	John Rogers	Megan Ronk	Val Hale	Anja Bendel	J.J. Ament	Lance Gaebe	Aaron Scheibe	Courtney Dentlinger	Kerrie Tyndall	Therese Varela
ENVIRON. POC	Hope Stockwell	John Tippetts	Sindy Smith	Jerimiah Rieman	Martha Rudolph	Dave Glatt	Nick Emme	Tricia Scott	John Mitchell	Ryan Cook Flynn

Table 1. State stakeholders

MT:

Brad Johnson (Chairman; Public Service Commission)
 John Rogers (Chief Business Development Officer)
 Ms. Hope Stockwell (Legislative Environmental Policy Office)

ID:

Scott Pugrud (Deputy Administrator; Office of Energy-Energy Policy and Programs)
 Megan Ronk (Director; Idaho Commerce)
 John Tippetts (Director; Idaho Dept. of Environmental Quality)

UT:

Laura Nelson (Governor's Energy Advisor and Executive Director, Governor's Office of Energy Development)
 Val Hale (Executive Director; Governor's Office of Economic Development)
 Ms. Sindy Smith (RDCC Coordinator)

WY:

Alan B. Minier (Chairman-Public Service Commission)
 Anja Bendel (President; Economic Development Association)
 Mr. Jerimiah Rieman (Natural Resources Policy Director)

CO:

Jeff Ackermann (CEO-Director, CO Energy Office)
 J.J. Ament (Chairman; Office of Economic Development & International Trade)
 Ms. Martha E. Rudolph (Environmental Programs Director)

ND:

Julie Fedorchak (Chairman-Commissioner; Public Service Commission)
 Lance Gaebe (Director; The Energy Infrastructure and Impact Office)
 Dave Glatt (Chief; Department of Health-Environmental Health)

SD:

Chris Nelson (Chairman; Public Utilities Commission)

Aaron Scheibe (Interim Commissioner; Office of Economic Development)

Nick Emme (Staff Attorney; Department of Environment and Natural Resources)

NE:

David Bracht (Director; Energy Office)

Courtney Dentlinger (Department Director; Department of Economic Development)

Ms. Tricia Scott (Department of Environmental Quality)

KS:

Jay Scott Emler (Chairman; Kansas Corporation Commission)

Kerrie Tyndall (Director of Economic Development; Office of Economic Development)

Mr. John Mitchell (Director, Division of Environment; Department of Health and Environment)

NM:

Tony Delfin (Acting Cabinet Secretary; Energy, Minerals, and Natural Resources Development)

Therese Varela (Division Director; Economic Development Department)

Mr. Ryan Cook Flynn (Secretary; Environment Department)

APPENDIX C -- Agenda

Regional Clean Energy Innovation Summit

Date: Sept. 19, 2016

Schedule: 9:30 am – 5:30 pm MST; Reception following until 7:00pm MST

Location: University of Colorado Boulder - Sustainability, Environment, Energy Complex (SEEC)
4001 Discovery Drive, Boulder, CO 80303

9:30 – 10:00 am	Check in and networking
10:00 – 10:05 am	Welcome: Peter Green, Deputy Laboratory Director, National Renewable Energy Laboratory
10:05 – 10:30 am	Keynote/Opening remarks – Former Colorado Governor Bill Ritter, Jr., now Director, Center for the New Energy Economy, Colorado State University --- High level points from Collaboratory economic impact report & 9 state North Central and Inter-mountain West region description (MT, ND, SD, NE, KS, CO, WY, UT, ID). Discuss how local, regional and national innovation clusters and multi-state collaborations can help solve energy challenges in the 21 st Century.
10:30 – 11:30 am	Panel Session #1: Regional energy needs Moderator: Bill Ritter, Director, Center for the New Energy Economy, Colorado State University Panelist #1: Martin Keller, Director, NREL (regional needs in renewables) Panelist #2: Mark Northam, Executive Director, School of Energy Resources, University of Wyoming (regional needs in fossil fuels and carbon capture) Panelist #3: Robert Simm, Senior Vice President, MWH/Stantec (regional needs in water) Panelist #4: Frank Prager, VP for Environmental Affairs, Xcel Energy (regional needs in electric grid and transmission)
11:30 – 12:15 pm	Lunch and networking
12:15 – 12:45 pm	Session #2: Federal and state government perspectives Moderator: Paul Johnson, President, Colorado School of Mines Keynote: Colorado Governor John Hickenlooper
1:00 – 1:45 pm	Session #3: Federal perspectives on regional clean energy innovation partnerships followed by Q&A Introduction -- Chancellor Phil DiStefano, University of Colorado Boulder Keynote – Franklin (Lynn) Orr, Under Secretary for Science and Energy, United States Department of Energy
2:00 – 3:30 pm	Session #4: Facilitated topic area breakout session discussions Introduction and format for breakout sessions: Terri Fiez, Vice Chancellor for Research, University of Colorado Boulder Breakout session A: Grid and Storage Facilitator: Tony Dean, Vice President of Research and Technology, Colorado School of Mines Session leaders: Bryan Hannegan, National Renewable Energy Lab and Dan Zimmerle, CSU

Breakout session B: Food/Energy/Water

Facilitator: Jeff Muhs, Associate Director, Energy Institute at Colorado State University
Session leaders: Ken Carlson, Colorado State University and Tzahi Cath, Colorado School of Mines

Breakout session C: Energy/Climate/Efficiency

Facilitator: Terri Fiez, Vice Chancellor for Research, University of Colorado- Boulder
Session leaders: Dag Nummedal, Colorado School of Mines and Bob McGrath, University of Colorado-Boulder

Breakout session D: Renewable sources

Facilitator: Barbara Goodman, Executive Director | Institutional Planning, Integration & Development, NREL

Session leaders: Bryan Willson, Colorado State University and Ryan Gill, University of Colorado-Boulder

3:45 – 4:30 pm Session #5: Breakout session reports
Moderator: Tony Dean, Vice President of Research & Technology, Colorado School of Mines
Each breakout session will summarize highlights to the full group

4:30 – 5:30 pm Session #6: Summary for a clean energy innovation region
Moderator: Alan Rudolph, Vice President for Research, Colorado State University
Entire group will discuss information covered by speakers and breakout sessions. Open discussion on framework for a regional partnership with next steps.

Note: A portal will be open until Sept 22, 2016 at www.regionalsummit.org to accumulate feedback and additional ideas. Feedback from the Sept 19, 2016 meeting and the portal will be summarized in a full report and sent to U.S. Department of Energy by Sept 23, 2016.

5:30 pm Meeting adjournment followed by a networking reception ending at 7:00pm

Breakout session questions:

1. To facilitate today's activities, four topic areas have been proposed (Grid and Storage; Food/Energy/Water; Energy/Climate; Renewable Sources). These are not meant to be exclusive of the regional needs. Are there additional focus areas that should be added to the list?
2. What are the regional strengths and opportunities in the four proposed topic areas and any topic areas added? Is there an overarching theme for this region that should be pursued? If so, please summarize.
3. Commercial deployment of energy technologies is required to have impact at a large scale. What are the opportunities for industry and research communities in developing and deploying next generation energy innovations at a large scale in our region?
4. How can we align anticipated research topics with state policies that become key drivers of deployment?
5. Building on the idea of regional innovation partnerships based on the RPSEA model (www.RPSEA.org), what are additional inputs to the process and governance that should be considered? How can we structure the regional entity in order to receive effective collaboration across the multi-state region?

APPENDIX D – General Session Notes

Regional Clean Innovation Summit 9/19/16

Welcome: Summit Goals

Peter Green, Deputy Laboratory Director, National Renewable Energy Laboratory (Dr. Green serves on the Colorado Energy Research Collaboratory Executive Board)

- Ten states are represented at this Summit
 - MT, ND, SD, NE, KS, CO, WY, UT, ID and NM.
- Goal: To develop a regional approach to Clean Energy Innovation.
 - By defining technologies of value, we can minimize environmental impacts by maximizing collaboration across region.
 - The approach should have significant economic impact.
- Today's Focus: Develop action items for follow-up so that what is done here today is sustainable.
- Three questions for each group:
 - Identify regional strengths and challenges;
 - Discuss opportunities for public/private partnership and commercial deployment; and
 - Understand how public policy decision will impact and influence achieving these goals.
- Four Breakout Sessions focused on Four Areas of Research
 - Grid and Storage
 - Energy/Climate
 - Food/Energy/Water
 - Renewables
- NREL: world-class; work with developing communities, small companies, developing nations – involvement, synergistic with NREL's mission.

Keynote and Opening Remarks: Collaboratory Impact Report and Multi-State Collaborations to Solve Energy Challenges

Former Colorado Governor Bill Ritter, Jr., now Founder and Director, Center for the New Energy Economy, Colorado State University

- Setting the context of the discussion:
 - International, national and local context regarding those who care about clean energy on the consumption and production sides
 - People in the business of power generation (utilities, etc.) are facing uncertainty, both nationally and internationally.
 - There is 100% agreement that decarbonization is part of our energy future
 - Need to find a balance between the technologies and the financing mechanisms that will enable this decarbonization.
 - On the federal level, Obama has used executive power to enact emissions reduction policies, including the 2013 Clean Power Plan: 32% emissions reduction by 2030
 - Utilities were convening to discuss how to comply until Supreme Court stayed the plan
 - Market of uncertainty over next 5-20 years

- Decarbonization will be part of it
 - Technology and finance sides must be married together
 - Predictability for utilities
 - Note that technology is often out ahead of utilities, and regulation holds utilities back from adopting technology
- Regionally, how do we comply with the EPA Clean Power Plan?
 - Western state attributes
 - 85% of Nevada is federal land, CO also has a great deal of federal land;
 - Low population so wind farms can be built on private land without much trouble;
 - Coal, natural gas, solar, and wind energy resources; in addition to the energy/water nexus
 - Water as a resource is critical for energy production
 - Natural gas: what are the solutions around methane capture?
 - WY largest coal producing state – local economies; could be a model for rest of the country; and
 - CO Colorado first to modernize rules around methane under Governor Hickenlooper.
 - Great national laboratories in CO (NOAA, NIST)
 - Industry partners in cooperation with oil & gas companies as well as rest of the sector, like Vestas wind technologies that have a huge economic impact
 - Medium and small companies across the West are growing as well
- Between 2008 and 2015, the Collaboratory investment of almost \$8 million from state of Colorado funds was leveraged to attract more than \$96 million in externally sponsored research, with an associated impact on the local economy of almost \$194 million
- Colorado Energy Research Collaboratory caused direct research impact of \$94M from an \$8M investment. This success helps to inform our thinking about how to take a regional approach.
 - The Collaboratory can be expanded regionally beyond Colorado
 - The region can take advantage of Mission Innovation resources to help make progress toward deep decarbonization and decrease uncertainty for utilities
- Questions to consider today:
 - When it comes to deployment, what's the best way to work with utilities, labs, and finance organization to get to the point where we can utilize these technologies?
 - Utilities are affected by regulation so there can be challenges deploying technology when it comes out of universities
 - How can we shorten the gap/create pathways toward broad deployment?
 - How do we think about the business of utilities and look at how to use distributed generation, etc. toward these goals?
 - Western Utility Model—how do we think about the business of distributed direction?
 - How do we do this without increasing costs for those who can't afford it?
 - For example, coal miners in WY? We need to justly transition these economies
 - Bill Ritter wrote “Powering Forward,” including a chapter on justice for communities that have been devastated by decarbonization
 - How do we ensure research from the labs is relevant to this future?

Session #1 – Regional Energy Needs Panel

- For NREL, how can we provide solutions from the lab regionally?
 - Martin Keller (Director, NREL): We need to think about what's next
 - Solar and wind have made huge progress in cost reductions and deployment
 - Are we at the point where we have done enough with the technology?
 - The main concern is the energy being used in transportation and industry
 - 50% of carbon emission is caused by automobiles
 - How do we find ways to offset that energy use using renewables toward this decarbonization goal?
 - Using renewables in the future to decrease consumption, alternative fuels such as biofuels, etc.
 - We are well positioned in our region with academics, industry, working with the national labs to identify what is needed to close the gaps
- What is the status of the coal industry and where that can go toward decarbonization in this region?
 - Mark Northam (Executive Director, School of Energy Resources, University of Wyoming): This is an interesting time, where fossil fuels have cycles of sustainability concerns versus environmental concerns.
 - Coal production is currently in decline due to natural gas and decarbonization concerns. The market is declining, but in this region, all states burn coal—fossil fuels supply 2/3 of the energy used in the region
 - WY, MT, ND, and CO are top coal producers; and
 - ND, WY, CO, and UT in top 10 for natural gas production
 - We need to find technology that allows us to use these resources without increasing carbon emissions—this is key to the economic health of the region
 - Look at carbon capture, storage, utilization. Capture technology is not economic; transportation infrastructure for carbon is nonexistent; and we don't have a product for carbon utilization at this point. Storage is a public safety concern. There is resistance in the United States to use storage under the surface
 - Technology is not the issue: cost, public perception, and regulatory scheme are the challenges
- What about water?
 - Robert Simm (Sr. Vice President, MHW/Stantec): There's a paradigm shift in how we view water and wastewater treatment
 - 50% of all energy used from water supply is for pumping. Can we look at saving costs here?
 - 20% of energy is flushed down toilets and sinks—can we capture that heat energy and use it?
 - Wastewater contains 10 times the energy needed to treat it. We need to get to net neutrality in wastewater treatment. We need to find efficiency in treatment processes, potentially turn food waste into biogas, or use algae microbial systems to treat and clean water
 - Collaboration is key to finding solutions. Research and Development through universities and national labs, for example: John Hopkins University has lab space and funds research as a collaborative partner on a zero sludge system

- Utilities—how to plan for uncertainty?
 - Frank Prager (VP for Environmental Affairs, Xcel Energy): Xcel has been trying to model how to move forward in this future for utilities
 - Regionally, they don't plan much at that level. States make policies, and CO doesn't have a regional market, but there is some interest in creating an RTO for western utilities
 - It could be cheaper if states cooperate. A larger market could balance the uncertainty from higher penetrations of renewables
 - Studies being done by NREL/NCAR on forecasting are useful to utilities.
 - The number one research need is storage for wind and solar. Even then, we may not be able to get to complete decarbonization—look to advanced nuclear, carbon capture and storage, and so on around 2050. Until then, we can go far with renewables
- What about the private sector research needs?
 - Robert Simm: Wastewater heat capture is a research need. We need to look into reducing biofouling and optimizing heat transfer fluids to extract heat from wastewater
 - Northam: (*In response to question on why Wyoming isn't doing more to develop wind/renewable resources.*) Wyoming doesn't have export capacity to develop renewables; the economy is based on fossil fuel production. Natural gas has reduced state coffers by one-third. Incentivizing wind is not a priority because there's no transmission capacity and no public acceptance culturally. Note that this is an example of a big difference in the region, despite all the similarities in other areas
 - Could develop an internal market for renewable production, perhaps to use in state for manufacturing using fossil products. This would create a brand new economic sector that could displace fossil products/revenues
- Do we need new technology or just to deploy existing technology? How do we spend money—innovate or deploy?
 - Martin Keller: it would be a mistake to stop innovation
 - We need policy and a plan for grid storage. We need to innovate to see how we can offset transportation and industrial energy use with renewables
 - Do we need new technology or just the ability to deploy it? Transmission constraints. Should we focus on deploying and transmission versus innovation?
 - NREL – truth is in the middle, you need both. Lack a plan re: storage . . . innovation needed for the future; develop a plan to implement in the future.
 - Mark Northam: U.S. is the biggest innovator but we cannot do it alone—this is an international issue
 - CO₂ doesn't stop at our borders. How can we bring our ideas and those of other countries as world leaders in innovation to solve global decarbonization problems?
- How much do utility policies need to change to get the full benefit of new technologies?
 - Frank Prager: California and New York are recreating the utility as a platform for energy retail transactions
 - We need to be prudent about how we approach those models. Our priority as a utility is reliability
 - We need to invest in the grid first because it makes everything possible and enables the mission
 - We also need to create new utility-customer relationships as interaction increase with smart devices

- We need to get the rules right – cost to price, net energy metering is a dicey issue for Xcel and a better model for state regulation. Xcel working on a pilot for pricing (pending before the commission)
- Distributed energy resources, working with customers, old ways won't work with adding high penetration renewables.

Questions from the Audience for Panel #1

Q: How can we shift from what the industry can tolerate to what the economy can tolerate?

- Bill Ritter: Have to go beyond the Clean Energy Plan. Aspect of this is political with campaign finance and political barriers on every side which can impede our progress
 - When sectors get involved in politics, makes regional conversation more important. We may be able to transition by building on regional agreements

Q: What about NH₃ liquid fuel as storage for wind/solar? Are you familiar with hemp as a fuel?

- Martin Keller: It is very important to find a platform in the need of industry. Platform molecules like NH₃ are an opportunity to consider. We need a platform where this can be used for transport or industry. Hemp as replacement for biodiesel – how scalable?
- Mark Northam: More interested in liquefied natural gas. (Hemp has to be left at the Wyoming/Colorado border – said in jest). This can be used for carbon capture for coal plants inexpensively. Refrigerated liquids are promising but we need multiple mechanisms for all applications

Q: Geo-engineering research? In the future are we going to look into net-negative carbon?

- Mark Northam: Friedman in DOE Vail Energy Summit projected by 2050, we will need net negative carbon emissions to maintain the 2-degree limit. We are not doing enough to limit carbon now

Q: From an innovation perspective, how can farmers and ranchers help in the economy? How can ranchers participate in the carbon market?

- Technology and Financing mechanisms are needed
- Agriculture and Forestry need to be involved
- Carbon accounting is another emerging area

Q: How are extreme events (oil spills, pipeline) framing the larger discussion?

- Bill Ritter: The political climate is tense; many places have only economic impact in mind. The challenge is there is a patchwork of policies and priorities in each of the 50 states. We can't be too righteous about our own position in order to find common ground, especially when environmental concerns run contrary to economic development
- Frank Prager: Customers all want clean energy but if it's more expensive, interest declines. Innovation is needed to make it reliable and affordable

Q: What kinds of storage excite the utilities?

- Frank Prager: Batteries—we have a ways to go with this technology, along with pumped hydro and an integration of renewables
 - The fear is that with increased wind production, we'll have negative costs at night with excess energy
 - Open to anything in terms of new clean technology, although utility scale is most effective as a grid resource

Session #2 – Federal and State Government Perspectives

Introduction: Paul Johnson, President, Colorado School of Mines (President Johnson serves on the Colorado Energy Research Authority Board).

- Gov. Hickenlooper was a geologist. He recently wrote a book about his life in politics. He was the mayor of Denver when Bill Ritter was the Governor of Colorado.

Session #2 – Keynote Speaker: Colorado State Governor John Hickenlooper

- The challenge of getting states together is how do you create a collaborator approach?
- Daunting Global Challenges
 - By 2040, energy consumption will be up 50-60%
 - Over the last five years, cost of wind dropped, 2009-2015 solar dropped by 78%
 - The polls I've seen on the topic of global challenges cite climate change and cyber security
- Shifting to Cleaner Energy and Innovations in Natural Gas
 - As a geologist, it's so dramatically different than how geologists have thought about energy
 - Innovations in directional drilling and fracking have advanced in recent years
 - The challenge is that even natural gas adds to climate challenges
 - Colorado is the first state to impose statewide operational regulations on methane emissions resulting in drastic reduction in fugitive emissions
 - Natural gas is a bridge fuel and will play a significant role going forward. The credible models show a significant amount of natural gas as a transition fuel to a clean energy economy
- Colorado had the first renewable standard passed by voters
 - The percentage of energy from renewable sources rose from 1% to 15% in Colorado over a 10 year span (2004-2014)
 - Wind production was 67% of energy mix for one-hour period last year for Xcel (highest in the country at that time).
 - By 2020 Xcel will provide 30% of energy from clean/renewable sources.
- Success Equation is Pairing of Innovation and Collaboration
 - The challenges with wind energy, however, are in intermittency and storage.
 - Nevada Governor investing more in innovation in battery storage than any other state in country.
 - The common denominators for successful integration of clean energies are innovation and collaboration. You can have one without the other, but you sacrifice scale and impact
 - Changes are mostly driven by markets, incentives, etc.
- Clean Energy as it Relates to Workforce
 - We have a lot of jobs in the coal industry in Colorado. We need to provide coal communities with basic tools and incentives to help them transition
 - Gov. Ritter created what I say was the first of the clean power plants. He talked effectively about the number of jobs that will come out of clean tech. By being able to leverage market forces, things will go faster and better in the context of the climate imperative. If we can move to a low-carbon energy system, why wouldn't we?
- Collaboration: Expanding R&D funding, expansion of public/private partnerships
 - Support public good of reliable energy with continued funding for innovative R&D; the Collaboratory is a great model for this regionally

- \$8M in State Funds leveraged to nearly \$100M, with a total economic impact of almost \$200M in working with DOE
 - Federal labs are tied with top research labs in this region resulting in innovative collaborations. Our region has some of the top researchers in the world, the resiliency of infra-structure, and significant research resulting in improving carbon-energy efficiency.
 - Los Alamos National Laboratory
 - Sandia National Laboratory
 - Idaho National Laboratory
 - National Renewable Energy Laboratory
- Our degree of Collaboration is good, but needs to scale up
 - Opportunity: improve detection of methane leaks from natural gas and how to respond to them
 - The ability to be able to detect leaks will result in costs coming down much faster than originally anticipated. Each of these collaborative ecosystems have different strengths, can nurture the resources, uphold the highest standard for public health and protect the environments
- Looking at these collaborations, we are going to solve this—
 - You're a long way from where you need to go, but you've done a lot. I congratulate you

Questions from the Audience for Governor Hickenlooper

Q: I have heard that most of the tax credits have gone to the very wealthy, such as electric cars. Will subsidizing clean energy create any opportunities for those in lower income brackets?

- Innovations for the benefit of the wealthy eventually trickle down to middle class, etc.
- Cheapest and cleanest energy is insulation and conservation. We still have programs around that effort. Low-income weatherization is still a big area of focus, but funding for these programs are impacted by the decline of oil and gas

Q: What would you like to see come out of this session to empower changes described?

- Getting states to work together is very powerful. Once you get the synergy of diverse efforts combined, you can get a dramatic magnitude of innovation
- In the next session of the legislature, we will discuss the notion of getting regional states to work together. More local government funding resources is key. A gasoline tax is not enough, so we are looking for different sources besides DOT funding. Federally, the expectation is for local sources to provide revenue which will take a larger match of resources.
- The challenge in the state legislature is to avoid making it a partisan issue. Anything the Governor does has to go through the legislature, and the Governor cannot change the rules or compel utilities to change. Energy issues are always partisan
- The larger question, is given that we won't pay more for energy in our homes and businesses, how much cleaner can our energy be at the same cost? What can we do? It shouldn't be a partisan issue to make cleaner air
- Doing the "honest hard work of listening" is the true work of state legislatures

Q: The public acceptance of the reality of climate change and the need to decarbonize needs to be handled through education. What can Colorado do to set an example in educating the public, including young people, about climate change and unacceptable levels of global warming?

- These areas are a real challenge. Universities are powerful in doing that work
- Rhythms and cycles in weather create skepticism, but science is valid

Q: This morning we heard from the panel about balancing in terms of power, and the example was California wanting control. Can organizations like the Western Governors Association work together to make balancing easier in the west?

- Legislatures do desire to play a larger role in controlling/balancing/energy
- Western governors are in the process of integrating water plants
- Generally, governors get along great despite the partisan issue – they are our "hope for mankind."
- Governors are willing to take the lead and take more risks compared to some other politicians

Session #3 – Federal Perspectives on Regional Clean Energy Innovation

Partnerships

Introduction: Chancellor Phil DiStefano, University of Colorado Boulder
(Chancellor DiStefano is on the Collaboratory Board.)

- Welcome to SEEC (Sustainability, Energy and Environment Complex) -- home to 1,000 environmental studies students who are pursuing the same goals that you are/collaborating with Government labs)
- We value our partners in the Collaboratory and are pleased to have both Colorado Governors participating, along with Paul Johnson, Colorado School of Mines (CSM), Teri Fiez; CU Boulder; Tony Dean, CSM; Alan Rudolph, Colorado State University; and Bob McGrath, RASEI, a partnership of CU Boulder and NREL
- Honored to introduce Dr. Lynn Orr, Principal Advisor and Deputy Under Secretary of Energy

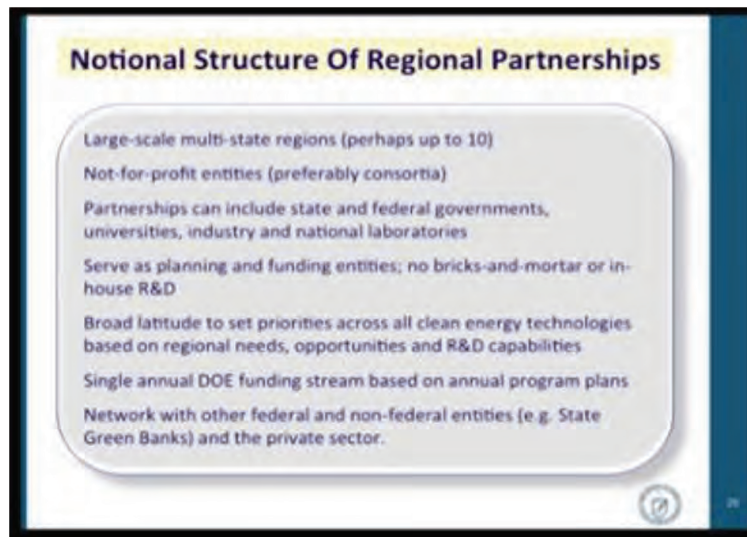
Session #3 – Keynote Speaker: Dr. Franklin “Lynn” Orr, Under Secretary for Science and Energy at the Department of Energy

- Why are we here?
- The future of the U.S. depends on our ability to provide economic security, steward environmental sustainability and provide secure access to energy
- Energy is so woven through the entirety of modern society that the way we supply and use it is fundamental
- *Global temperature anomaly: review of climate data trends*
- Mission Innovation – how do we do something about the state of our planet on a global scale?
 - Paris Agreement Commitments
 - US & China issued major commitments in 2014—set the stage for the Paris negotiation
 - Commitments
 - Accord will take place when 55 countries representing at least 55% of global emissions have joined—so far 27 countries have joined
 - 180 countries have signed the Paris Agreement
 - 27 countries representing 39% of global emissions
 - Mission Innovation is a commitment of the United States and 19 other world leaders to commit to a doubling of public investment in clean energy R&D over the next 5 years
 - The 20 countries represent 75% of the world’s CO2 emissions from electricity, and more than 80% of the world’s clean energy R&D investment

- Mission Innovation: United States
 - Within DOE, new funding in FY2017 for Mission Innovation (MI) will be focused on early state R&D
 - Thinking about how to deploy additional resources if they are available
 - Dr. Orr's position as Under Secretary for Science and Energy
 - I oversee a fully stocked portfolio of energy RD&D based on a solid foundation of fundamental science and computing
 - Using innovative research collaborations, we need to work across the full range of that portfolio as a fundamental key to the Mission Innovation commitment
- Innovative discovery – Opportunities for Collaborations
 - Gov. Hickenlooper set him up well
 - Gov. Ritter is doing this work
 - Not only support individual researchers, support major research labs. The tasks are too expensive for individual universities
 - DOE supports big user facilities, etc., the kinds of things that bring scientists together.
 - Energy Frontier Research Centers (EFRCs)
 - \$2-\$4M per year, a bunch of collaborators are brought together as a group to work on a focused problem.
 - For example in local states:
 - Colorado
 - Montana
 - New Mexico
 - Utah
 - Research projects can range from material science to catalysis and/or batteries
 - Energy Innovation Hubs
 - Advanced Manufacturing Initiative: projects have a unique role to support and complement Mission Innovation
 - GOAL: Reduce by 50% in 10 years the life-cycle energy consumption of manufactured goods by targeting the production and use of advanced manufacturing technologies
 - Example: Oak Ridge Manufacturing Demonstration Facility
 - ARPA-E
 - Unique Role to Complement DOE Applied Energy R&D
 - What would it take to get technologies to market?
 - 36 new companies and 10 or so new products on the market.
 - Success rate is about 2%: there are good proposals being left on the table
 - Regional Clean Energy Innovation Partnerships
 - Suggested as possible mechanism to address more of these proposals
 - Regional Partnerships: Senate Report Language
 - "The Committee urges the Department to utilize investments through existing regional capabilities that include industry, universities, and state and regional economic development assets. The Committee further encourages the national laboratories to expand their geographic outreach through

people and access to specialized equipment and user facilities in order to contribute to the success of these regional initiatives.”

- Looking to take advantage of expertise distributed around the country
 - \$110M proposed in FY17 budget
 - Expand Innovation Opportunities:
 - Fostering regional ecosystems
 - Regionally-designed and led innovation agendas
 - Complement current DOE national and fuel-specific R&D programs
 - Plenty of opportunities to capitalize more effectively regionally on assets as well as power resources
 - QTR recognized that there are many ways to capitalize on systems – we should be thinking about how to manage and make more efficient the systems and their interconnections as well as their individual components (energy systems integration)
 - National Research Council’s 2012 Report, “Rising to the Challenge”--generally regional industrial development has not been connected to state and regional industrial development. Bridging the gap can ...
 - Power Generation Sources and Water Withdrawals for Power General Vary Greatly by Region (map)
 - Water creates and uses energy
 - We should be thinking about the efficiency of the systems
 - Maps of U.S. renewable resources and regional CO2 sources both show opportunity to make the whole be greater than the sum of its parts
 - Regional CO2 Sources with Access to Sequestration Options or Associated Infrastructure
- Notional Structure of Regional Partnerships



- Regional Innovation Partnerships: Possible Activities
 - Issue R&D grants/contracts
 - Support regional competitions/prizes
 - Offer credit enhancements to help attract private & “patient” capital for commercial start-ups
 - Provide data and analysis to support innovation activities
 - Connect education and job training with innovation opportunities
 - Assist start-ups with facilities and project management
- Regional Partnerships: Ecosystems Complement DOE Programs
 - Not looking to stop any efforts.
 - Leadership from non-federal stakeholders
 - Want to partner with local/state/regional levels
 - Looking for diversity of approaches
- Status of FY2017 Mission Innovation Funding Request
- How we deploy additional funds as they come in is important: Apply Quadrennial Technology Review (QTR) analysis to guide research direction and portfolio
- Conclusion
 - Currently deciding priorities for FY18 and 5-year notional plan for areas of opportunity
 - Many lines of evidence demonstrate climate change induced by human activities
 - A lot more left to do and a lot more players are needed
 - A portfolio approach is required
 - Regional innovational partnerships can play an essential role
 - Thank you for your efforts and for protecting the planet at the same time

Dr. Orr’s PP slide deck (31 slides) can be found here: <http://www.regionalsummit.org/live-streaming/>

Audience Questions for Dr. Lynn Orr

Q: How do we reconcile research opportunities outlined in QTR with innovative ideas?

- Wide range of opportunities in QTR; looking to harness creativity of regional partnerships to see what’s worth looking at and then find resources that can challenge them.
- Not trying to be too prescriptive in the QTR

Q: With the emerging themes around grid modernization, energy and water, are these higher priorities?

- We’re putting resources into grid modernization as well as other areas, and looking for what the regional efforts could bring to the party
- We need Congressional authorization to do this, but not being too prescriptive – we won’t try to hard wire

Q: Is carbon tax within the scope of Mission Innovation?

- Energy R&D will be mostly focused on technology aspects, but carbon tax would influence how those markets work -- so they would matter as well

Q: In working with national labs, we have to cover their cost share, which can be prohibitive to innovation and challenging to universities. Are we burdening national labs with this challenge, and thereby not using them effectively as a resource?

- We realize the way we work with companies is challenging, and are working to streamline CRADAs
- We are also working to make facilities more accessible, to help entrepreneurs partner with lab scientists. There is definitely a need for this

- National labs also have other big roles: security, user facilities, and federal regulations to comply with
- The Secretary of Energy is trying to work more strategically with lab directors in streamlining operations and directives, in helping share best practices, and in trying to improve lab planning processes

Q: In the non-profit corporation model a 1:1 cost share doubling federal investment allows institutions to become sustainable in the long term, but they need to raise funds to keep things going. How will these non-profits be managed?

- We will be listening to see if other structures make sense. There is some history that this model has worked

Q: How does industry participate? Small companies?

- At the beginning, we don't require cost share. We should be flexible enough to allow both large and small companies
- The cost share percentage depends on the stage of the R&D project
- We would like to see partnerships with companies of a variety of sizes

Session #4: Facilitated Topic Area Breakout Session Discussions

Introduction and format for breakout sessions: Terri Fiez, Vice Chancellor for Research and Innovation, University of Colorado Boulder

- Overview of breakout sessions
- Up to this point, you've had a chance to listen. Now, we're going to put you to work
- The intention of the whole meeting is to get all of you together
- Breakout areas were defined by the Collaboratory as being important in this region
- Topic Areas:
 - A. Grid and Storage
 - B. Food/Energy/Water
 - C. Energy/Climate/Efficiency
 - D. Renewable Sources

The goal of the breakout sessions were to discover how we might form this regional partnership.

Please see Appendices E – H for individual breakout session note taken during pre-summit calls, as well as at the Sept 19, 2016 Summit.

Session #5: Breakout Session Reports

Moderator: Tony Dean, Vice President of Research & Technology, Colorado School of Mines

Each breakout session spokesperson summarized highlights to the full group. See the notes from Session #5 below.

A: GRID AND STORAGE

Facilitator: Tony Dean, Vice President of Research & Technology, Colorado School of Mines

Session leaders: Bryan Hannegan, National Renewable Energy Lab and Dan Zimmerle, Colorado State University. Dan Zimmerle led the discussion.

CONTEXT: The Grid on the western slope is divided into many balancing areas, and is fairly spread out due to mountains.

- The underlying energy systems in the area are a diverse mix from coal, oil, gas, wind, etc.
- There is a diverse climate regime from New Mexico to Montana.

Strengths and opportunities

- Region strength: very large renewable resource with high penetration. Also a good geographical and energy system mix
 - Very large wind, solar resources—uniquely positioned for regional play on high penetrations of renewables
- Cross-cutting technology areas.
- Good analysis and deployment capabilities at scale—industry, labs, etc.
- Why? We have a good idea of forecasting: loads, wind, etc. There will be development of new system models. Possibility of large-scale storage
- Driver behind this for displacement: move to a carbon-neutral system will impact carbon sectors and we need to bridge across those
- Geographical disparity—different climates, etc.
- Micro grids
 - Military bases, tourism areas, and data centers could be launch pads for this kind of deployment
 - Different kind of pull than resiliency on east coast
 - Danger Possibilities: Earthquake or Fire
 - More greening, military focus in this region
 - Good physical research infrastructure for demos on both sides of this; good lab testbeds; could possibly get some cities involved at the next scale
 - Private sectors, startups in this space; large amount of companies in distributed control space
- Our research community and industrial communities can work together.

B: FOOD / ENERGY / WATER

Facilitator: Jeff Muhs, Associate Director, Energy Institute at Colorado State University

Session leaders: Ken Carlson, Colorado State University and Tzahi Cath, Colorado School of Mines. Jeff Muhs led the discussion.

CONTEXT: We need to look at this beyond just the technology, but at the life-cycle cost analysis, finding balance, looking at a holistic perspective and at underlying principles before technology development.

Strengths and Opportunities

- Region has a rich history of an abundance of energy and food production constrained by water, which is unique for this particular region for this topic
 - A number of unmet needs are in the agricultural system that could be market pulls; what are ways we could do a tech push in this market?
 - Office of Science had a good model for technology development as does ARPA-E. From a deployment perspective, finding ways to incentivize these demos so market pull can take hold
 - A lot of interest in biofuels in the region that is related to the water constraints. Rather than food, think of agriculture. Agriculture can account for 80% of water withdrawal and energy is obviously required; smart irrigation is an ongoing research area
 - Oil and gas produced water, there is a need for effort around that, and several research projects are ongoing in this area right now
 - The nexus of a food/energy system creates the need to look at a multidisciplinary approach to projects. This region has to have a systems approach
 - Bring in social sciences, economics, policy, and ecosystems/environment with technology.
 - Is DOE interested in system work for this partnership?
 - (Bryan Willson) We don't know yet
 - DOE wants commercialization, and in doing so has to also consider social, economic, policy barriers—those are key in water issues
 - Eco-system scale and environmental scales are concerns
 - Economy of scale. Large scale is easy to recover nutrients. Have to think about it at this regional scale as well, as nutrients are harder to recover
-

C: ENERGY / CLIMATE / Efficiency

Facilitator: Terri Fiez, Vice Chancellor for Research and Innovation, University of Colorado- Boulder

Session leaders: Dag Nummedal, Colorado School of Mines and Bob McGrath, University of Colorado- Boulder. Dag Nummedal and Bob McGrath co-led discussion

CONTEXT: Significant overlap with all the other breakout sessions on this topic.

- Acknowledged the wide variety and number of organizations - clearly shows interest in Mission Innovation. New friends. Will find the appropriate electronic method to communicate. Start a web site?
 - In the next to the last issue of "Science" magazine, there was an article about economic impact across the planet, plotted in terms of bright light/industrial activity. No economic activity in Africa or South America. That's not the direction we want to go in.
- I would like to stress the importance of social science and education. We need to coordinate and overlap with other groups
 - There are important contributions in terms of energy efficiency that we will need to follow up on

Strengths and Opportunities

- Several people brought up important issues about public policy and behavioral sciences
 - Huge need for K-12, general public, and elected officials level
- Our region is rich in fossil and renewable energy sources, which makes us unique as a net exporter of both energy sources
- Implementing gigawatt-level storage where the energy is produced is a big question. Is it possible for us to do this here?
- The need for expanded distribution systems is very important if we are generating and storing all these renewables
- Air quality is a big interest in Denver, Salt Lake City, and surrounding areas. Regionally, there are health quality issues directly related to energy generation and emissions. We can tap into our regional strengths of climate modeling and micro-climate modeling to find solutions.
- Technology innovation and spin-off is important: Utah, Wyoming, and Colorado have been emphasizing this for a long time
- Follow Up: This group has already been organizing follow-up sessions on energy and climate.
- If we get our researchers talking and working together, they will find opportunities/building blocks for the future

D: RENEWABLE SOURCES

Facilitator: Barbara Goodman, Executive Director | Institutional Planning, Integration & Development, NREL

Session leaders: Bryan Willson, Colorado State University, and Ryan Gill, University of Colorado-Boulder. Bryan Willson led the discussion.

CONTEXT: Ask the group what topics we should consider as regional under “Renewables”:

- Recycling, efficiency, and reuse—looking at waste in manufacturing and reuse
- We need more systems analysis to integrate topics
- Does nuclear have a role and where does it go?
- Perhaps we're too broad—pick one or two we can really focus on with available resources

Strengths and Opportunities

- Rich in renewables in region such as wind, solar and biomass, but not homogeneous; intellectual resources and DOE and other federal labs such as NOAA
 - This area could be the Silicon Valley of renewables
 - Much of the research coming out of labs tends to be just out of reach of commercialization—need a translational R&D
- Create innovation standard for market pull with certified new technologies, can bridge gap due to costs
- Create something similar to DOD for set of requirements for regional center
- Regional ARPA-E able to define requirements for the region
- A lot of talk on models around organization
- Look at simplifying our message—is there an analogous program to "Stop smoking"?

APPENDIX E -- Grid and Storage

(Notes taken during pre-summit call and during summit)

Regional Clean Energy Summit: Session #A

Pre-Summit Breakout Session Topic Conference Call

14 September 2016

Attendees

- Bryan Willson – Executive Director, Energy Institute, Colorado State University CSU
- Maury Dobbie – Executive Director, Colorado Energy Research Collaboratory and Assistant Director, Center for the New Energy Economy, CSU
- David Breedker – Managing Director, Microgrid Systems Lab, Santa Fe NM
- Chad Wocken – EERC, University of North Dakota
- Dan Zimmerle – Director, Electric Power Systems Laboratory, Mechanical Engineering, CSU
- Poorva Bedge – Student, College of Engineering, CSU
- Melissa Fox – Program Director, Applied Energy Programs, Las Alamos National Lab. Participating as Grid Modernization Director
- Bob McGrath – RASEI Director, University of Colorado Boulder/NREL
- Babs Marrone – Biofuels Laboratory manager, Las Alamos National Lab
- Bryan Hannegan – Associate Lab Director for Energy Systems Integration, NREL

Snapshot Summary:

1Q: Additional Regional Focus

- Grid Modernization is key. Changing storage prices will change the decisions.
- Asking [about intersection with Regional Grid Initiative] from the Grid Modernization side
 - Put forward an originally Colorado-specific partnership discussion that could be expanded. Grid modernization landscape
 - Mountain West is changing from central station to distributed generation. Goal could be to get to 50% penetration
 - Needs power electronics, energy storage, weather prediction (NOAA, NCAR)

2Q: Regional Strengths

- great resources on weather at institutions, as well as companies
- CSU has a lot going in atmospheric sciences plus a lot of industry
- NSF/ESIF, INEL (beyond microgrids to mesogrid)
- SolarTAC
- XCEL is building a microgrid with Panasonic near DIA
- Fort Collins' FortZED beyond

- New Mexico
 - Sandia (leading role)
 - Multiple projects with DOD on:
 - Microgrids
 - Energy security
 - Solar/wind research,
 - Microgrid Systems Lab – UNM has microgrid facility,
- Cybersecurity
 - Smart Grid consortium for EPSCOR, New Mexico Tech, Sandia.
 - Incubating effort around distributed level
 - at the device level: NREL working with PNNL, coordinated under Grid Modernization Initiative
- Topology
 - We have a lot of hydropower, from big plants to smaller plants in the mountains. Are there other environmental drivers?
 - New Mexico Tech has a working group
 - Los Alamos Lab - Internal efforts on energy storage

3Q: Developing and deploying on large scale

- Industry partners (many). Ex: Spirae, Positive Energies, Tendril,
- Utilities
 - Los Alamos Department of Public Utilities is an unregulated MUNI.
 - Also does water & gas
- Water
 - Denver Water, XCEL could be interesting
 - Research campuses could be an opportunity
 - Think about National Western Center
- Energy Storage
 - Batteries from ND to NM, very different
 - Can look at this on a 50-state mix
- Atmospheric Sciences
 - 20+ years from now
 - Resilience as an explicit discussion item

4Q: Aligning research topics with state policies driving deployment

- Policy is interesting :ranging from policy to economics to workforce training
- where can we demonstrate planning tools?
 - New generation coming in behind the meter, changes nature of how to operate.
 - CNEE as a regional resource

Q5: Organizational around partnership

- Early preparation ideal
- What is our Super strength?
- What is our 5 year vision?

Grid and Storage Breakout Session Notes

September 19, 2016

Registered Attendees

Carol	Adkins	Sandia National Laboratories	Director, Energy Technologies and System Solutions
Poorva	Bedge	Colorado state University	Graduate Student
Rebecca	Cantwell	Colorado Solar Energy Industries Association	Executive Director
Chris	Dorrington	Montana Department of Environmental Quality	Air, Energy, Mining Division Administrator
Allister	Frazier	University of Colorado Boulder	PhD Student
Barbara	Goodman	National Renewable Energy Laboratory	Executive Director
Peter	Green	National Renewable Energy Laboratory	Deputy Lab Director, Science & Technology
Bryan	Hannegan	National Renewable Energy Laboratory	Associate Director
Monica	Heintz	Sierra Nevada Club	Denver Metro Network Technical Advisory Team Lead
Gregor	Henze	University of Colorado Boulder	Professor
Jeffrey	King	Colorado Energy Office	Business Development Manager
Vandana	Koelsch	CleanTech Open	Regional Training Chair
Alice	Madden	CU Law School	Executive Director Getches-Wilkinson Center
Michael	Marshak	University of Colorado Boulder	Assistant Professor, Chemistry/RASEI
Brian	Oehler	Cleantech Open	State Director, Colorado
Wes	Parham	Xcel Energy	State Government Affairs Manager
Omar	Ruiz	Turner Construction	MEP Engineer
Christine	Shapard	Colorado Cleantech Industries Association	Executive Director
Sarah	Spencer-Workman	Noresco	Manager- Sustainability Services
Sid	Suryanarayanan	Colorado State University	Assoc. Prof.
Daniel	Zimmerle	Colorado State University	Senior Research Associate
Paul	Zoby	American Energy Assets	Chief Executive Officer

Question1: Additional Topics

- Clean Coal / Nuclear – Is this included in the Energy /Climate/Efficiency section?

Question 2: Regional Strengths and Opportunities

- Strengths of our region:
 - Plentiful R.E resources
 - Geographic diversity
 - Many Balancing areas
 - High density of labs – NOAA/NIST/NREL and research universities
 - Atmospheric sciences
 - Good start up culture
 - Private sector partners (Vestas, Spirae, Panasonic)
 - Fast growth
 - Many test beds
 - Fast growth - Good timing
 - Distributed controls
 - Sustainable building design – largescale projects underway
 - Research in materials for storage, coatings, nanomaterials
 - Lots of hydro – large scale storage
 - Concentrated Solar Power – NREL / Sandia
 - Nuclear – INL
 - NREL – hydrogen (little interest from industry)
 - Large customer base willing to innovate and adopt (tourism, retail, new home builders)

- Physical infrastructure and microgrid expertise – Powerhouse, ESIF, solar tak, RTCs, Idaho test grid
- Supercomputing
- Technology deployment application experience
- Energy policy research group + education – CNEE, RMI, NREL analysis
- Mix of red and blue state
- Opportunities for our region
 - Grid Integration
 - Better integration between industry and academic research opportunities
 - companies
 - Aerospace company's/military bases – they need to link better
 - PUC governance
 - Complex grid – many balancing areas
 - Coal plant retirement and need for replacement infrastructure
 - No ISO, electricity market
 - Resources in our region are more distributed than other regions
- Challenges
 - Animal migration

Question 3: Large scale Impact Commercial Deployment of Energy Technologies

Question 4: Aligning Topics with State Policies to Become Key Deployment Drivers

- Land use policies
- Movement from oil, gas, coal economies
- Lots of federal land investment
- Few vehicle manufacturers in region though lots of research activity
- Regulatory framework for hydrogen
- Royalty streams of oil, gas versus other land uses

Two main areas we want to focus on:

- Bulk Renewables/Storage
 - Good bulk RE
 - Good forecasting
 - Multiple BA
 - Large scale storage including H2, hydro
 - Need for economic development
 - Replace oil and gas economy
 - Geographic diversity
 - Cyber and resilience
- Interest in local energy systems
 - Microgrids
 - Large CCI customers
 - Military bases
 - Grid integration /distribution energy
 - Physical infrastructure available
 - Private sector
 - Startups
 - Distributed controls
 - Deployment experience

Comments made after Summit on Sept 22, 2016

From: Hannegan, Bryan [mailto:Bryan.Hannegan@nrel.gov]
Sent: Thursday, September 22, 2016 9:09 AM
To: Dobbie, Maury
Cc: Willson, Bryan; Zimmerle, Dan
Subject: Re: Great Summit!

Maury, during the Summit, one of the ideas I had regarding the focus of a potential RCEIP is around helping cities, communities, industrial parks, college campuses, etc. achieve clean energy systems at a 10-100 MW or larger scale. Many of these entities have ambitious clean energy or renewables goals (e.g. City of Boulder 100% RE ambition) but no realistic and detailed path to get there. The non-profit org under construction could serve as a one-stop gateway to the impressive scientific capabilities of the region (NREL, NCAR, NOAA, CU, CSU, Mines, etc.)

If we go down the “grid+storage” pathway we facilitated this would be a natural mechanism to address both large-scale grids and microgrids as well. This full “energy system” look would naturally include energy/water as well as natural gas, heating/cooling, etc. If we also include on our focus understanding how those future clean energy systems will have to change and adapt to weather and climate variability, we also can capture elements of the “energy/climate” breakout. A renewable energy future is highly dependent on weather and climate, and our regional strengths in weather and climate research are unmatched.

Call it a “Front Range Regional Partnership for Weather, Climate and Energy Systems” and give it the goal of demonstrating 6-10 regional examples of progress towards a clean energy future at the industrial park/city/community/campus scale... This would dovetail nicely with the planning regional partnerships as part of the DOE Grid Modernization Initiative.

Am happy to discuss further if this is of interest as you put your thoughts together on a potential response.

—

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APPENDIX F -- Food/Energy/Water

(Notes taken during pre-summit call and during summit)

Regional Clean Energy Summit: Session #B

Pre-Summit Breakout Session Topic Conference Call

14 September 2016

Attendees

1. Bryan Willson – Executive Director, Energy Institute, Colorado State University (CSU)
2. Maury Dobbie – Executive Director, Colorado Energy Research Collaboratory and Assistant Director, Center for the New Energy Economy, CSU
3. Ken Carlson - Professor, Civil and Environmental Engineering, CSU
4. Robin Newmark – Associate Lab Director for Analysis and Decision Support, NREL
5. Dag Nummedal – Director, Colorado Energy Research Institute, Research Focus: greenhouse gas emissions, Colorado School of Mines (CSM)
6. Carol Sturman – Co-Founder, Sturman Industries
7. Don Langley – Consultant with Bob McGrath, Industry interface with RASEI, history in the electric power business, appointed position with Aurora Water
8. Tzahi Cath – Professor of Civil & Environmental Engineering, Research Focus: water treatment technologies, CSM
9. David Swanson – Professor of Biology, Director of Missouri River Institute, University of South Dakota
10. Babs Marrone – Los Alamos National Lab, Biofuels Program Manager, can also represent New Mexico consortium between LANL, UNM, NMSU, and NM Tech, on biotechnology for energy & food security
11. Krysten Averyt - Associate Director For Science, University of Colorado Boulder
12. Ashwin Dhanasekar- CSU (note taker for this breakout)

Question 1: Additional Topics

- A key area of shared interest is optimizing water utilization and energy use with agricultural irrigation. Specifically, biofuel crops, since there are ongoing projects with multiple organizations in the 10-state region. Future projects that would also benefit stakeholders across the region include:
 - Development and permitting of unconventional water sources for irrigation
 - Unconventional water sources may include oil field produced water, industrial wastewater, and domestic wastewater
 - Modeling efforts seek to
 - Identify and quantify these sources,
 - Determine wastewater qualities,
 - Understand treatment requirements, and
 - Develop cost/benefit analyses that include the full life-cycle (including transportation)

- This project would lead to implementation of the infrastructure required to use these water sources for irrigation
- The project would involve:
 - Universities for modeling and bench scale treatment studies,
 - Engineering consulting firms for designing infrastructure,
 - Construction companies for building infrastructure,
 - Government regulatory agencies for permitting, and
 - Financiers for funding the scaled up applications at sites throughout the region.
- Water is the limiting factor in expanding agricultural activity in much of the region. Enhanced irrigation techniques, including the project described above, will allow the utilization of water to be optimized and lead to additional crop production.
- Additional technology that should be evaluated and demonstrated to enhance irrigated cropland includes:
 - Advanced monitoring techniques for nutrient and water application,
 - Biotechnology for genetically modifying plants for drought tolerance,
 - Soil supplements to improve the microbial communities that plants require, and
 - Remote plant health monitoring.
- Agriculture to support the production of biofuels is of great interest in the region.
 - In addition to the topics discussed above for optimizing water utilization in irrigated croplands, there is ongoing research to model the impacts of:
 - Transitioning land from food to biofuel crops in terms of climate change,
 - Food security,
 - Biodiversity,
 - Ecosystems and other potential effects.
 - This research would be the foundation for projects that would provide support for the biofuel production ecosystem throughout the region.
- The region has significant existing strengths in this energy-water-agriculture nexus including:
 - Experience with irrigating biofuel crops with produced water while minimizing treatment requirements,
 - Utilizing low energy irrigation systems, and
 - Using biotechnology to genetically modify biofuel plants for drought tolerance.

Question 2: Regional Strengths and Opportunities

- Collaboratory summary of Food/Energy/Water (Robin Newmark Provided- see last two pages of this document)
- Rollup of Energy/Water/Nexus meeting from last fall, also a regional workshop
 - Part of an ERC on water infrastructure in urban settings.
 - Focus on decentralization, efficiency, potable reuse, increased focus on urban runoff & storm water capture
 - R&D related to oil & gas, decision support tools, new NSF grant from NSF on how to manage wastewater treatment centers

- Drought Tolerance in Plants
 - Biotech to genetically modify plants, both bioenergy & food crops
 - Remote monitoring of plant health
 - Direct monitoring of soils
 - Monitoring is close to commercialization; technology is on Mars Rover now, not sure if there is a commercial partner
 - Ken- Irrigation and plant needs and drought conditions with switch grass and canola, in collaboration with ag sciences in green houses, non-food crops and biofuels that don't use fresh water
- Regional opportunity & strength is the threat of wildfire and impact of wildfire on watersheds. Wildfire modeling sponsored by DOE & USDA.
- Regional strength also in livestock & the contribution of livestock for methane emissions.
- An additional topic is completely different climate conditions, so need to define what type of collaborations to be competitive
 - Ken – diversity can be a good thing
- How adoption of biofuels would impact the Missouri River
 - Includes conflicts, energy, biodiversity, cultural (how do people value ecosystem services provided by the region), lots of modeling on putting back CRP land and other bioenergy / biofuels
 - Definition of bioenergy is 2nd generation biofuel crops
- NREL identifies energy, water, food as part of their sustainability metrics. 4 areas:
 - Water & climate impacts into energy sector modeling analysis, production cost models & lifecycle analysis,
 - Technology, renewables, low-water biofuels,
 - Energy / water systems solutions, supply and demand. Have worked with Army on bases. Integrated planning in developing countries. Tribal issues.
 - Energy Systems integration, energy thermal. Unique hardware-in-the-loop in ESIF. Partnerships include CSM (low temperature recovery).
- **SWARMS: Southwest and Rocky Mountain South**, with Sandia.
 - See 1 page fact sheet from Robin Newmark re: program in 3rd year
 - Not externally funded, but there are some seed projects. State of New Mexico was going to devote funds. “Meeting of the willing”, but no outside funding.
 - Through Energy Water initiative, 19 different companies. State & Government Entities
 - One issue is regional testbeds
- Irrigation of biofuels with produced water, drought tolerance
 - Grew 2 biofuels, switchgrass & canola, with various amount of produced water. Have done in greenhouses, moving to open production next spring. Really agriculture/energy/ water, not food.
 - Also looking at recovering energy from wastewater treatment to make urban agriculture commercially viable in Denver Metro area
 - Looking at sewer heat recovery. Treating to irrigation standards

- We should reach out to Jill Cooper about Energy Water Initiative
- 4 areas: Irrigation – have systems that can irrigate a field on a 9 volt water & intelligent water. Fit for purpose water. System on use of NH3.
- Over-allocated water resources
 - Interest in using water more efficiency
 - Runs “prairie water system”
 - Has appointment with Aurora Water, 3rd largest center in Colorado
- DOE highlighted grid modernization, water utilization, & smart manufacturing

Question 3: Large scale Impact Commercial Deployment of Energy Technologies

- Commercialization opportunities
 - Tradeoffs -- CSM also working on
 - Commercialization is important at NREL
 - Have incubators and approaches to finance
 - Colorado industry partners are strong: MWH, CH2M Hill, Anadarko, Noble.
 - Injectors for hemp oil

Question 4: Aligning Topics with State Policies to Become Key Deployment Drivers

- Policy is a limiter and has environmental impact

Question 5: Organizational Around Partnership

- NSF ERC processes: strong industrial components and industrial advisory boards
- Engagement with industry
 - Public resource managers
 - Large scale governance v. individual power plant or wastewater

After Call Comments

See SWARMS Fact Sheets from Robin Newmark, below

Energy and Climate

Southwest and Rocky Mountains South (SWaRMS) – Water/Energy Nexus Partnership

The SWaRMS Partnership is a National Laboratory-led consortium of regional stakeholders working together to address water-energy challenges.

Our Challenge – In the Southwest and Southern Rocky Mountains, energy production, energy resource extraction, and other high volume water users compete for limited surface and ground water supplies that are vulnerable to droughts, over appropriation, and especially regionally significant climate change.

These vulnerabilities present a challenge to energy and resource planners in the region, which is one of the fastest growing in the nation. The partnership has been established to help link established local, state, and federal energy and water science and technology programs with innovative modeling, analysis, and engineering research to help better address the regions emerging climate-ecosystem-water-energy challenges.

The partnership has held two energy-water planning workshops, in Santa Fe in 2014 and in Denver in 2015. Over one hundred state, federal, university, and private groups from Arizona, Colorado, New Mexico, Nevada, Oklahoma, Utah, and Wyoming are participating.

Our focus: enough water for energy and enough energy for water.



Regionally Appropriate Energy-Water-Ecosystem Solutions



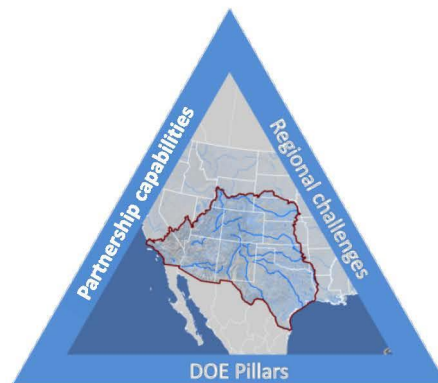
SWaRMS – Water/Energy Nexus Partnership

Our Goals – Solutions to our unique regional challenges will require a broad range of science and technology research efforts that include modeling and analysis, pilot demonstration and testing, and performance validation. Priority efforts identified include:

- Development of **decision support tools** to improve integrated water and energy resource planning through: regional climate and geospatial analysis, data integration, water and energy infrastructure “big data” analysis, and regulatory and policy changes to support sustainable energy and water use.
- Research to **reduce fresh water use and improve water use efficiency** in energy development and production through: use of desalination, low water-use renewable energy, produced water reuse, non-water based drilling fluids, low water consumption thermoelectric cooling and carbon capture technologies, and improved water efficiency for alternative fuels.
- Research and development to **reduce energy use in non-traditional water treatment** to: increase the use of non-traditional waters in thermoelectric power production, oil and gas development, hydraulic fracturing, petroleum refining, municipal and commercial water augmentation, and for agricultural use.

Envisioned Outcome - Cooperation at the federal, regional, and state level will improve the resiliency of the energy and water infrastructures while achieving sustainable, adaptive, water and energy resource management. It will improve regional planning, and help in the conservation of fresh water in all sectors - supporting **the appropriate water for the appropriate application**.

The role of SWaRMS is to help facilitate regional cooperation in science-based research and development for emerging regional and national energy water nexus programs and projects. The intent is to help support regional and national team-building and collaboration on energy water related modeling, analysis, engineering, and testing in order to improve and accelerate innovative technology and policy development and implementation.



For more information please contact:

Name: Andy Wolfsberg
E-mail: awolf@lanl.gov

Name: Robin Newmark
E-mail: robin.newmark@nrel.gov

Name: Vince Tidwell
E-mail: vctidwe@sandia.gov

Food/Energy/Water Breakout Session Notes
September 19, 2016

Registered Attendees

Kristen	Averyt	University of Colorado Boulder	Associate Director for Science
Matthew	Bailey	Advisor to Government of Alberta	International advisor IoT
Mary	Berry	University of South Dakota	Vice President for Research and Sponsored Programs
Ken	Carlson	Colorado State University	Professor
Tzahi	Cath	Colorado School of Mines	Professor
Rachel	Cheetham	Sierra Nevada Corporation	CoS
Jeni	Cross	Institute for the Built Environment, CSU	Director of Research
Ashwin	Dhanasekar	Colorado State University	Research Associate
Maury	Dobbie	Collaboratory	Assistant Director
William	Doe	University of Colorado - Boulder	Research Opportunities Coordinator
Kevin	Doran	U.S. Department of Energy	Senior Advisor
David	Ellerbroek	AECOM	Senior Vice President
Justin	Fazzari	Commerce Dept. - Economic Development Admin.	Economic Development Representative (CO and UT)
Danielle	Felix	University of Colorado Boulder, RASEI	Assistant Director
Cindy	Furse	University of Utah	Assoc. VP for Research
Shemin	Ge	University of Colorado, Geological Sciences	Professor and Dept Chair
Michael	Hagood	Idaho National Laboratory (INL)	Director, Program Development
Paul	Hallacher	University of Colorado	Consultant
Robert	Hau	Sperry Van Ness	Managing Partner
David	Hiller	Colorado Energy Research Collaboratory	Past Director
Jocelyn	Hittle	Colorado State University	Director, Denver Program Development
Donald	Langley	DC Langley Energy Consulting	CTO
Caitlin	Leibert	Chipotle	Sustainability Manager
Matt	Mansfield	Flood and Peterson	Risk Advisor
Jim	Marchiori	University of Colorado Denver	Executive Director, Global Energy Management Prog
Jeff	Muhs	Colorado State University Energy Institute	Associate Director
Robin	Newmark	National Renewable Energy Laboratory	Associate Laboratory Director
Scott	Palo	University of Colorado	Associate Dean of Research, College of Engineering
Tom	Plant	CNEE	Senior Policy Advisor
Jennifer	Ramsey	National Renewable Energy Laboratory	Project Leader, Innovation & Entrepreneurship
Ken	Reardon	Colorado State University	Professor
Z. Jason	Ren	University of Colorado Boulder	Associate Professor
Ryan	Richards	Colorado School of Mines	Associate Vice President for Research
Carlos	Romero	New Mexico Tech	Associate VP, Research & Economic Dev.
Joe	Ryan	University of Colorado Boulder	Professor
Robert	Simm	MWH/Stantec	Senior Vice President
Mark	Sirangelo	Colorado Energy Research Collaboratory	Director, Authority Board
Lee	Spangler	Montana State University	Director, Energy Research Institute
John	Spear	Colorado School of Mines	Associate Vice President for Research
John	Turner	National Renewable Energy Lab	Research Fellow
Kelly	Underell	Colorado Innovation Network	Deputy Director
Heidi	VanGenderen	U.S. Department of Energy	Director of External Affairs
Mark	Wdowik	Colorado State University	Assistant Vice President for Research
Chad	Wocken	UND Energy & Environmental Research Center	Principal Engineer
Ronggui	Yang	University of Colorado Boulder	Professor

Question 1: Additional Topics

- Review of the Pre-Summit Energy/Water/Food Topics Discussed
 - Development/Permitting of Unconventional Water Sources
 - Modeling - Water/Wastewater Quality
 - Bench-scale Treatment
 - Government Regulatory Agencies
 - Drought Tolerance
 - Agriculture to support the production of biofuels
- One thing that was missing is transportation. Transportation related issues is a huge topic that was not mentioned
 - Transportation is more of an energy end use
 - Important to include mobility
- Wildlife and Wildlife Habitat for Energy Projects
 - New solar facilities, wind, etc, wildlife can come into play
 - Wildlife and habitat could be more important
 - Climate Change - Migratory patterns change
- Social Systems, regulatory barriers/policy barriers, balancing regions
- Financial Systems, distribution and transmission
 - Really tackling the problem would mean taking a systems approach
- Life-Cycle Analysis, is definitely needed. CSU - We are definitely trying to get that working
 - Urban-Sustainability

Question 2: Regional Strengths and Opportunities

- Regional Topics to begin discussion:
 - Irrigation
 - Biofuels
 - Oil and Gas
 - Hydroelectric
 - Climate Modeling (Impacts on Regional Resources)
 - Carbon Measurements
 - Modeling Fluid flow through fractured media
- Assets - What's unique about the region?
 - Public Lands
 - Indian Country
 - Growing Population
 - Water Availability (Constraints throughout the region)
 - Energy Resources
 - Food Production
 - Relatively Low Population
- Sustainability of food system operations
 - It is good to set it up as a start for this region
 - The impact will be nationwide
 - States are mostly made by small rural communities
 - The economy of scale plays a huge role in water treatment. It has a lot of efficiency to improve and arrive at a sustainable solution.

- Needs:
 - Research on urban rural linkages. Western states history of energy development. Need to make sure that informs future paths.
 - 80% of use of water went to food production. No one wants to talk about that
 - There is a competition for our water
 - Projection of ag-water balance
 - Infrastructure. The authorities stretch across different levels
 - The competing interest for water can change with areas
 - In order to be pro-active, and to avoid drought, it takes an enormous amount of collaboration
 - Improve real-time information monitoring data about water, snow mass or stream flow
 - Another need is for collaborative planning to avoid having different water interests.
 - Need for federal authorities. Money is not allocated for drought per se
- Questions:
 - How do you optimize the state/local/federal government for addressing drought relief?
 - How would this new landscape of energy-water use change the national hydrological system for various scales?
 - How to merge hydrological systems with local eco-systems?
 - How to align organizations to address this? Governance changes that can transcend boundaries.
- Concerns - Water disposal due to fracking operations.
 - How do we handle intermixing of regulations? We need to have those discussions more often.
 - Main messages from the tribe - Each tribe is unique. Their use varies.
 - The consultation effort should be done. They are here, you can consult with them.
 - Tribes have always said we are connected, find balance, holistic type of approaches
 - We don't talk in terms of science, they keep it simple, just work it out.
 - Overarching Theme - We need to take a holistic approach, there should be a complete overall system that work with all these individual aspects
 - Social Systems would be great to work with on a life cycle analysis
 - We can find solutions only when we involve a systems approach
 - Are we taking an NSF approach to this or are we taking the DOE approach?
 - That needs to be addressed at the leadership levels
 - We do need to have technical components
 - Water for Energy is the start, then how does it impact agriculture?
 - You make produced water reusable for agriculture
 - Cost of doing it is significant
 - Crops for biofuels
 - If we need to go carbon negative, biofuels will have climate impacts, other similar issues

Question 3: Large Scale Impact Commercial Deployment of Energy Technologies

- There is a large difference between small scale to large scale and then to pilot scale.
 - If you somehow incentivize the pilot scale work, it could be deployed very quickly
 - Test Beds are the core
 - It is a platform where people from different worlds come together to test different concepts
 - There are ongoing inter-agency conversations about waste water treatment
- Opportunities in Colorado for produced water disposal
 - There's definitely a lot of activity on the renewables front
 - To use negative carbon concept, how can we better integrate renewables into our backbone energy grid
 - With food energy water, energy and food for water reuse is always good when there is an actual governance in place which helps. It changes the whole economics
 - Easier to work with state helped public lands than federal helped public lands
 - Transmission lines are pretty complicated
 - They cross through multiple lines: state, federal, private, etc.
- Academia v. industry and lab
 - What are the hurdles in commercialization?
 - Why doesn't industry and NREL accept academic research right away?
 - Is it financial concerns?
 - Infrastructure and overarching guidance are some of the reasons
- Small research projects, combine them together, and then try to commercialize it is key

Question 4: Aligning Topics with State Policies to Become Key Deployment Drivers

- We are going to have to fit the technology into existing structure of policy
- For policy-makers, the agencies involved are diverse
 - If you make a list of who regulates what related to your work, it makes more sense when it is served to them on a silver platter, so that they can make a case for processing it
- Academia needs to step in and provide that pathway
- There must be policy research that will do this for you. Communication between people developing technology and people working on policy would help a lot
- [Drawn on Flipchart]
 - Circles - Techno Wars, Policy, LCA, Ecosystems, Social Sciences, Economics
 - Big Circle: System

APPENDIX G -- Energy/Climate/Efficiency

(Notes taken during pre-summit call and during summit)

Regional Clean Energy Summit: Session #C

Pre-Summit Breakout Session Topic Conference Call

14 September 2016

Attendees

1. Bryan Willson – Executive Director, Energy Institute, Colorado State University (CSU)
2. Maury Dobbie – Executive Director, Colorado Energy Research Collaboratory and Assistant Director, Center for the New Energy Economy, CSU
3. Mark Northrup – Executive Director, School of Energy Resources, U. of Wyoming
4. Bob McGrath – Director of RASEI, Colorado University Boulder/NREL
5. George Guthrie – Leads subsurface work on geothermal & CO2 capture, LANL
6. Babs Marrone – Biofuels Program Manager, LANL
7. Dag Nummedal – Directo, Colorado Energy Research Institute (CERI), Colorado School of Mines
8. Carol Sturman – Sturman Industries, Co-Founder, asked to participate by Newmont Mining
9. Jason Begger – Executive Director, Wyoming Infrastructure Authority, new integrated test center
10. Don Langley – Consultant, industry interface with RASEI
11. Scott Neil – DCP Midstream, VP Engineering
12. Andy Wildenberg – E3Power, Denver Commercial Energy Audits
13. Robin Newmark – NREL, Associate Lab Director, Energy Analysis and Decision Support

Snapshot Summary

Question1: Additional Topics

- CO2 capture and utilization is important
 - Methane Capture
 - Regional partnerships: linkages with Dakotas on carbon capture
 - Multiple links in region with methane producers
 - Value in National Labs
- Energy/Water
 - Linking energy, climate, environmental issues, atmospheric modeling, micro climate
 - NOAA and CIRES
 - Aerospace and NASA
 - All have industry partners

Question 2: Regional Strengths and Opportunities

- NOAA, CERES, lots of presence from aerospace around remote sensing
 - Largest university-funded NASA presence
- (WY): Carbon Storage

Page 47 of 61

- Moving carbon capture and utilization down the pipeline
- Carbon storage in Valley of death
- Cryogenic Carbon Capture
 - DOE support: being done at Brigham Young
 - In carbon storage, they're working with pressure management and water utilities
 - Integrated Test Center. Will be used by X-Prize Foundation. Facility being built
- (NM): Capabilities in the area in ground-based & remote satellite capabilities
 - Solar spectrometers & point sensors
 - Applying to global program sponsored by DOE
 - Have been applied regionally to looking at coal-fired power plants
 - Particulate monitoring to other energy-related products
 - Wood / pyrolysis

Question 3: Large scale Impact Commercial Deployment of Energy Technologies

- Government taking on mobility side on drop-in fuels
 - Need opportunities for renewable fuels
- Residential energy audits
 - Clients are Xcel
 - People get audits but don't act on results
 - Behavior is important. Xcel only tracks improvements
- Need to see movement to utilization of CO2 as a resource
- New plants have CO2 injection, but often has CO2 H2S from amines
 - Hot gas recovery is expensive
 - Getting rid of benzene, etc.
- National Electric Cooperative, several utilities
 - Getting ready to issue an RFP for potential tenants; will announce Q1 2017

Question 4: Aligning Topics with State Policies to Become Key Deployment Drivers

- Policies around distributed power
 - Obstacle to cleaner [technologies]
- NREL does a great deal of policy support, integration, and work with tribal group
- CU's legal staff will participate

Question #5: Organizational around partnership

- Technology Transfer is key

Food/Energy/Water Breakout Session Notes

September 19, 2016

Registered Attendees

Michael	Aire	Newmont Mining	Director, Energy & Environment
Tammie	Borders	Idaho National Laboratory	Business Development
David	Budd	University of Colorado, Boulder	Professor, Geological Sciences
Richelle	Burnett	eChromic	CEO
Kipp	Coddington	University of Wyoming	Director, Carbon Management Institute
Brittany	Coyne	American Lung Association	Air Quality Program Coordinator
Anthony	Dean	Colorado School of Mines	Sr. VP for Research and Technology Transfer
Sarah	Derdowski	CU Denver, Global Energy Management Program	Director, Strategic Partnerships & Operations
Mike	Freeman	Rocky Mountain Innosphere	Innosphere
Don	Grant	University of Colorado Boulder	Professor
Harry	Gregory	The Climate Mobilization	Denver Chapter Organizer
Dietrich	Hoefner	Lewis Roca Rothgerber Christie LLP	Attorney
Mandi	Hutchinson	Colorado School of Mines	Assistant Research Faculty
Jack	Ihle	Xcel Energy	Director, Env. Policy
Derek	James	NORESKO	Director
Daniel	Kaffine	University of Colorado Boulder	Associate Professor
Kathleen	Lantz	NOAA; CIRES, University of Colorado	Research Scientist
Richard	Leonard	Battelle	CEO, Battelle Ecology Inc.
Jeff	Lyng	Center for the New Energy Economy	Center for the New Energy Economy
Anthony	Marchese	Colorado State University	Professor and Associate Dean
Shaun	McGrath	Environmental Protection Agency (EPA), Region 8	Regional Administrator, Region 8
Robert	McGrath	Renewable and Sustainable Energy Institute (RASEI)	Director
Kyle	Miller	Freestone Strategies	Principal
Dawn	Mullally	American Lung Association	Director of Air Quality and Transportation
Mark	Northam	University of Wyoming	School of Energy Resources
Arthur	Nozik	NREL and CU Boulder, Department of Chemistry	Sr, Research Fellow Emeritus & Research Professor
Dag	Nummedal	Colorado School of Mines	Director, Colorado Energy Institute
Gabrielle	Petron	NOAA Earth System Research Laboratory	Scientist
Ed	Raponi	Shell	Regional Finance Manager - Developing Gas Markets
Adam	Reed	University of Colorado Boulder	Education Director, RASEI
Bill	Ritter	Center for the New Energy Economy, Colorado State	Director
Sarah	Sandberg	Colorado Oil and Gas Association (COGA)	Chief Operating Officer
Sean	Shaheen	RASEI	Institute Fellow
Lyle	Shuey	Czero, Inc.	Chief Operating Officer
Sarah	Sloan	National Renewable Energy Laboratory	Director, Communications and Public Affairs
Dan	Stiles	Climate Reality Project	Senior Advisor and Outside General Counsel
Juan	Torres	Sandia National Laboratories	Deputy to the VP Energy & Climate Programs
Sandra	Vanderstoep	Alliance for Sustainable Colorado	Alliance for Sustainable Colorado
Will	Vaughan	Colorado School of Mines	Director, Technology Transfer
Jack	Waldorf	University of Colorado	Director of Federal Relations
Janna	West-Heiss	American Lung Association in Colorado	Denver Clean Cities Coordinator
Tamara	Zelikova	Department of Energy	AAAS Science & Technology Policy Fellow

Question 1: Additional Topics

- Public Policy and Behavioral Sciences
 - Education: K-12, legislators, and general public
 - Inform public school audience, climate change and energy efficiency, starting young, create curriculum that encourages thinking critically toward the future

Question 2: Regional Strengths and Opportunities

- Unique to our Region
 - Energy-rich: both fossil fuels and renewables, net exporter of both
 - Regional Themes: store energy near the source, our region, with low population density, may be ideal for development of gigawatt level storage, along with expanded electrical grid capabilities
 - Efficiencies:
 - Building technologies
 - Power managements and control systems
 - Help buildings with energy efficiency ad renewables
 - Zero-net energy consumption
 - Challenge is mismatch of demand at local site and generation of renewables, so storage problem
 - Energy efficiency is needed to help decarbonization in short term, develop new renewable tech that can remain efficient in the long term
 - Regional partnerships
 - We have a great regional partnership with Xcel, rebates, grassroots – need to get all involved not just the top
 - Look at stationary vs nonstationary storage with electric vehicles?
 - Air Quality: Energy/Climate themes important for air quality,
 - Leverage extensive regional expertise in climate and microclimate modules and prediction,
 - Capitalize on unique strengths, climate modelling and microclimate modelling, engage resources as Los Alamos, NCAR, and at University of Utah

Question 3: Large scale Impact Commercial Deployment of Energy Technologies

- Technology Innovation:
 - Start-ups! Denver and Salt Lake City have largest growing tech centers, maximize on innovations and commercialization abilities, also small/beginning entrepreneurs are innovators and need funding!
 - Need to apply advanced, practical and modern process controls, move toward advanced digital infrastructure, and
 - Use fuel-flexible engines, smart technologies, integrative technologies
 - How to integrate into existing or outdated systems (like coal plants)?

Question 4: Aligning Topics with State Policies to Become Key Deployment Drivers

- Public lands: Extensive public lands in our region, utilize as an advantage, could be both opportunity and a challenge
- Social: energy economy
 - How to do this so that economy is not effected to negatively
 - What is the role of the sciences in this?
 - Consumer behavior
 - Corporate responsibility to energy-related climate policy and grassroots initiatives

- Coal:
 - Over 50% of electricity in this region comes from coal,
 - There is still a large need for carbon storage and sequestration (CCS)
 - Strong renewable and research in renewable energy is needed to integrate with our extensive fossil fuels
 - Challenge and opportunity to facilitate the communication
- Follow-up: Create Topical Regional Workshops: Get the researchers talking
 - 1-Day workshops hosted by university in each state, topic is relevant to university/state focus/expertise, potentially ask universities to invite alumni?
 - Theme: research has to have a regional advantage, could request proposals in advance and researchers give 5-min pitch for workshop?
 - A collaborative online forum for discussion was suggested following the breakout session, perhaps a Linked-In page?
 - Link up databases regionally on who is doing what with research, even in industry

APPENDIX H -- Renewable Sources

(Notes taken during pre-summit call and during summit)

Regional Clean Energy Summit: Session #D

Pre-Summit Breakout Session Topic Conference Call

13 September 2016

Attendees

1. Bryan Willson – Executive Director, Energy Institute, Colorado State University (CSU)
2. Maury Dobbie – Executive Director, Colorado Energy Research Collaboratory and Assistant Director, Center for the New Energy Economy, CSU
3. John Chatburn – Idaho Governor’s Office of Energy Resources
4. Vicky Telles – Los Alamos National Laboratory
5. Chad Wocken – Principal Engineer, Fuels and Renewable Energy Lead, Energy and Environmental Research Center, North Dakota
6. Ryan Gill – RASEI, Associate Director for Research/Associate Professor of Chemical & Biological Engineering, University of Colorado Boulder
7. Tony Dean – Vice President of Research and Technology, Colorado School of Mines
8. Lee Spangler – Director, Energy Research Institute, Montana State University
9. Carol Sturman – Co-Founder, Sturman Industries
10. Jeff Muhs – Associate Director, Energy Institute, CSU
11. Karyn Murphy – Executive Assistant, Collaboratory (taking notes for this session)

Question1: Additional Topics

- Conversion technologies included in Renewable Energy topic area
- We fit in multiple topic areas, i.e. distributable power in future grid
 - Bryan: Maybe change Energy/Climate to Energy/Climate/Efficiencies to encompass more areas
 - Depends on where power comes from: fossil fuels is energy/climate, clean energy like solar or wind, renewables
- Additional source of new fuel: hemp

Question 2: Regional Strengths and Opportunities

- Montana has several strengths
 - Algae biofuels
 - CO2 storage
 - Wind
 - Expertise is in composite material for turbine blades at Montana State

- North Dakota Wind as a resource
 - Challenge is distribution
 - DOE on CO2 capture & EOR
 - Ag residue and ag resources
 - Wind is a deployment play, but also looking at integration
 - Energy resource analysis
- Possible that hemp is a strength if synergy between our two states

Question 3: Large Scale Impact Commercial Deployment of Energy Technologies

- Working with large IT companies and their databases
 - Efficiencies & cleaner operation are of interest on a national level
 - Opportunity may lie in finding industries interested in change
- Need distributed manufacturing
 - Need technologies at the scale of the resource
- Size of the investment is really large
 - Small deployments
 - Role that startups & entrepreneurs play
 - Good history to leverage
- I am coming more from the academic side
 - Will check with other people in my state before the Summit
 - In some areas, a big barrier for investors is regulatory uncertainty

Question 4: Aligning Topics with State Policies to Become Key Deployment Drivers

- Biofuels or renewable electricity, not only changes in subsidiaries, but across state lines.
 - What happens in MN can affect ND, and vice versa. Knowing where it is used and distributed is an important component
- Echoed Chad's remarks

Question 5: Organizational around partnership

- Herding cats, "need to move the food" and funding will be important to have partnership to work with common items for largest goal. Finding the largest things in commonality.
- For universities, valley of death for universities includes the need to publish. Need to move new technologies into market, but early stage disclosure threatens publishing credit. Private / university partnerships struggle
- Valley of death for high-tech is funding due to the need to demonstrate the new technology first
- Recognize that it's a big challenge

Closing Comments: What is missing?

- Back Up Systems and Test Beds
 - One of the things we have seen with new source technologies is back-up systems, [for example] if there are incorporation or interaction issues, the new technology is blamed. Maybe a test bed that won't bring a critical operation down is needed. Interaction can be tested without poisoning the waters of the new technology

- In the academic world we focus on devices, but in the real world, we have to figure out how systems work. Goes back to Carol's comment about looking at this as a system. Agree with your comment on testbeds. Should be explored.
- West versus East Coast Food Growth/Rural States
 - Also how much of the country's food is grown in this region? Whatever renewable energy strategy is decided, we are largely looking at rural states. Could be dramatically different from east or west coast.

Post-Call Comments

Sent: Wednesday, September 14, 2016 4:13 PM

Subject: Energy & Environmental Research Center - Expertise in renewable energy

Maury,

During the call yesterday, I spoke of ND energy resources, but failed to provide any info on EERC research capabilities.

I'm writing to provide you with a list of EERC expertise relevant to renewable energy which you can add to your list.

Gasification – We have decades of experience and ten test platforms ranging in scale from 1-lb/hr to 1-MW (thermal) capacity. These pilot scale gasifiers are available for hire. Additionally, these systems have formed the basis for a variety of technology advancements around syn-gas production from different feedstocks and technology platforms.

Syn-gas clean up and gas-to-liquid synthesis – EERC's expertise and capabilities in gas cleanup and GTL are paired with our pilot scale gasification systems and enable a testing of a wide range of operating conditions related to biomass conversion to liquid chemicals and fuels.

Advanced biofuels – The EERC, under contract to DARPA, developed a bio-oil (crop oils and algae) to specification complaint jet fuel. We have a variety of batch and fixed bed reactors capable of supporting catalyst testing/screening, process optimization, and scale-up of new processes for advanced biofuels.

I hope these are helpful to you and apologize for not providing them during the call yesterday.

Chad Wocken

Principal Engineer

Fuels and Renewable Energy Lead

Energy & Environmental Research Center

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Renewable Sources Breakout Session Notes
September 19, 2016

Registered and Actual Attendees

Janine	Benner	DOE - Office of EERE	Associate Assistant Secretary for EERE
Jeffrey	Cameron	RASEI	Institute Fellow
Rebecca	Cantwell	Colorado Solar Energy Industries Association	Executive Director
Brittany	Coyne	American Lung Association	Air Quality Program Coordinator
Carrie	Eckert	Renewable and Sustainable Energy Institute (RASEI)	Joint Appointment with NREL
Justin	Fazzari	Commerce Dept. - Economic Development Administration	Economic Development Representative (CO and UT)
Maria	Ghirardi	NREL	Fellow
Ryan	Gill	University of Colorado / RASEI	Slade Professor / Associate Director Biotechnology
Barbara	Goodman	National Renewable Energy Laboratory	Executive Director
Sue Ellen	Haupt	National Center for Atmospheric Research	Senior Scientist and Director, Weather Systems Program
Geoffrey	Herrig	Pipefitters Local 208	Business Representative
Greg	Jackson	Colorado School of Mines	Professor and Dept. Head
Paul	King	National Renewable Energy Laboratory	Scientist VI-Supervisor
Branko	Kosovic	National Center for Atmospheric Research	National Center for Atmospheric Research
Jeff	Lyng	Center for the New Energy Economy	
Devonie	McCamey	National Renewable Energy Laboratory	Communications Specialist
James	McQuarrie	Denver Metro Wastewater Reclamation District	Chief Innovation Officer
Carman	Melendrez	University of New Mexico	Research Faculty
Michael	Nastasi	University of Nebraska	Director of the Nebraska Center for Energy Science
Arthur	Nozik	NREL and CU Boulder, Department of Chemistry	Sr, Research Fellow Emeritus & Research Professor
Dan	Powers	CO-LABS	Director
Karen	Regan	CU Boulder	AVCR
Alan	Rudolph	Colorado State University	Vice President for Research
Sean	Shaheen	RASEI	Institute Fellow
Lyle	Shuey	Czero, Inc.	Chief Operating Officer
Juan	Torres	Sandia National Laboratories	Deputy to the VP Energy & Climate Programs
Jao	Van De Lagemaat	NREL	Center Director, Chemistry and Nanoscience center
Sandra	Vanderstoep	Alliance for Sustainable Colorado	
Brian	Vasel	NOAA / ESRL / GMD	Director of Observatories
Rongfu	Wen	University of Colorado	Research Associate
Janna	West-Heiss	American Lung Association in Colorado	Denver Clean Cities Coordinator
Dongliang	Zhao	University of Colorado Boulder	Research Associate

Question1: Additional Topics

- Recycling, efficiency, and reuse
- Potentially consider nuclear, either under energy or climate
- Do we consider waste and consumption? Potentially include under manufacturing
- Health issues related to energy. Perhaps consider health as a topic
- Policy and behavior as a driver of innovation has not been covered
- Metro wastewater – regional wastewater utility. Energy recycling is an issue
- Municipal solid waste is an opportunity; wastewater as well
- Need systems approach rather than discrete silos

Question 2: Regional Strengths and Opportunities

- Rich in terms of renewables across entire region: wind, solar, biomass
 - However, region isn't homogenous
- Region could evolve into Silicon Valley of renewable energy; great resources such as
 - DOE Labs: NREL, INL, Sandia, LANL
 - Non-DOE Labs: NOAA / NIST / NCAR / USDA / Forest Service
- Have worked through some of the social dynamics around collaboration through CERC;
 - However, would benefit from having innovation theorists at the table
- Nebraska:
 - Represent states east
 - Biofuels & cellulosic
 - Nebraska Center of Energy Science Research
 - Draws income from regional partner: Nebraska partner
- New Mexico:
 - Have 2 large labs
 - Universities
 - Electric utility management program
 - UNM in storage, NMSU
 - Region is resource rich. Rich in renewables as well as fossil, just don't have the loads
 - Won't consume in region
 - U of New Mexico: Summit in New Mexico
 - Breadth vs. depth
 - Have too many voices & messages
 - Need a "Quit Smoking" message
 - Message might be decarbonizing
 - Energy is a portfolio
 - Consider consolidating resources and fund 1-2 options that we can really expand on that will make the biggest difference for the nation and the planet—need to start narrowing down areas of focus rather than spread funding too thin
 - Great point: are there areas that have particular regional focus?
 - Need to create messaging around these efforts, some kind of campaign like quitting smoking—"quit carbon"
 - This involves not only renewables, but grid, etc.
 - A portfolio approach is necessary—particularly in this region
 - One thing that's exciting—photosynthesis and bio-sequestration research at various universities and NREL;
 - want to focus this on a small scale; capitalize on this on the regional level because it's a strength at these institutions
 - Emphasis on soil storage
 - Great strength in CO₂
 - Idaho has Center for Advanced Studies in Energy:
 - Lots of hydro, but no renewable energy standard,
 - Lots of renewables, and
 - Stranded coal assets, RPS expired
- Export power is a theme
- Montana Tech has extensive program in oil & gas; interest in renewables
- Woody biomass, water

Question 3: Large Scale Impact Commercial Deployment of Energy Technologies

- We have lots of resources in the ground
- What are the intellectual resources in this region, outside of CO? We could be looking at existing industries, or creating new companies
- What are the other companies who have track records in innovation in other states? Could have difficulties crossing state borders to maintain and establish partnerships
- How can we take early-stage R&D to commercial viability?
 - Requires a lot of different people coming together—for example, ARPA-E projects require you to have a commercialization effort. Need to think way beyond early stage
- We have technology that works and could be deployed at vastly greater scale but it's really about policy barriers and relative power of the utility versus the solar industry
 - The difference in resources, intellectual capability, everything needed to make it equal was absent—it takes intellectual/academic capacity to overcome some of these structural issues that are keeping renewables from hitting goals
 - Need some sort of repository that small companies can access or use to bolster their argument
 - Need to fully explore thought leadership in building these innovation ecosystems
- Utility partners are a critical component—have research labs and universities show their connectivity with the practitioners
 - Sometimes labs are just out of reach of where the practitioners need to go to make decisions about using a new technology
 - Need to see where you're going—be able to forecast this. Some sort of a translational element bridging between early stage and commercialization
- Think not about reinvesting in best practice, but retiring into a new pathway
- Need market pull: idea of an innovation standard – perhaps 15% of expenditures should be on “innovation certified new technologies” --- technologies that seek to bridge the gap

Question 4: Aligning Topics with State Policies to Become Key Deployment Drivers

- Pull for the technology instead of the push
 - Do buyers want it and when?
 - Can you predict when they need it?
 - What do utility resource planners need?
- A great deal of the west is served by public power cooperatives, 57 just in Colorado
 - Co-ops, public power—they tend to be more interested at the retail level in smaller scale technologies, so there's a pathway there (peak shaving, load shedding, etc.)
 - Larger investor-owned utilities focused on large 1,000 MW projects
- How do you create the markets that break out of the model of wait and see?
 - PTC show there's a sale on renewables in next few years
 - Energy efficiency deployed at ~2%, people generally coming around to idea of end use efficiency
 - Grappling with aged coal plants—do we invest in this asset or retire it?
 - Those are the opportunities where states can act—R&D needs to be meeting those needs in 5-10-15 year timeframe
- Couple of failures:
 - 2009 Stimulus funding, smart grid proposals
 - State of NM, but it failed because they didn't have their storage together. Different interests

- Rocky Mountain Smart Grid initiative – proposed setting up regional microgrids, primarily to support military bases. Didn't take off, but did get the bases to start – resulted in SPIDERS (Smart Power Infrastructure Demonstration for Energy Reliability and Security), quasi-success
- State of VT brought in smart grids and renewable technology; strength was they clearly defined their goals. Owners of the infrastructure aren't necessarily here, i.e. utility industry, stakeholders
- Coops are the most democratic utilities
 - Co-ops have FERC issues
 - Interest in community wind and biomass
- How can we align anticipated research topics with state policies that become key drivers of deployment?
 - In solar area, what do you observe with investor-owned utilities, co-ops, motivation of homeowners, etc.?
 - Co-ops are seeing opportunity in community wind, biomass, solar; harder time in areas with dispersed populations
 - Industry is very open to intellectual help and support; fertile ground for research and intellectual assistance
- Role of policy even down to local distribution company—can have a huge impact on technology adoption. Role of a regional center—innovation around thought leadership piece?
- Collaboration is not necessarily a strong point for tech/science people. Need to establish people who can help bridge that gap
 - That pendulum swings—there are times when labs are constantly competing due to funding, and then there are times like now that mandate collaboration and industry partnerships
 - Idea: bring boots-on-the-ground people together to share research ideas, how to bridge gap to commercialization, so everyone gets to see what is going on, could lead to on-the-spot collaborations
 - Seed money for projects that create collaboration?
 - People who actually do the work can understand each other
 - Peer group ASC – established to bring together direct current working group; there's buy-in from all parties; it's an open, shared experience

Question #5: Additional Inputs to the Process

- Models that work – on wastewater, national structure.
 - Key element is a symposia. 2-day sessions in various areas with industry involved
 - RPSEA
 - Building on the idea of regional innovation partnerships based on the RPSEA model (www.RPSEA.org), what are additional inputs to the process and governance that should be considered? How can we structure the regional entity in order to receive effective collaboration across the multi-state region?
 - On wastewater side, beginning to see connections with energy side—
 - Symposia with disparate entities coming together to see if synergies develop; every year they produce results
 - Create a structure that engages that sort of mash up
 - EDA.gov: coalitions pull together universities, private sector, nonprofits for manufacturing-specific initiatives—these communities make a lot of headway

- Project to improve solar forecasting at NCAR, brought together wide range of labs and industry and research groups
 - Workshops would start with panels with industry folks so they could see what their real needs were
 - Social scientists led brainstorming sessions
 - Then, academic partners and labs did publishable work, all worked toward a common goal
 - \$4.1 million over three years, \$2.5 million cost share
 - Fact that industry was bringing cost share—they had a buy in too
- Social sciences—this is an element that is key.
 - Human behavior is an area where there could be tremendous benefits—not only in determining how to run the organization, but involve end users
- Manufacturing initiatives: University of Utah / Utah State, www.eda.gov
- Concerns?
 - Cost share requirements for industry can make it prohibitive
 - Incentivize these
 - Hearing more requirements in the energy space—specific goals; the more consensus on what requirements drive us, the more incentive to drive these collaborations
 - DOD does this well, as they have a requirement to defend the country.
 - DOE has been loath to define that requirement. Uncommon collaboration
 - What would these be about? Some quantitative?
 - Depending on the group, who is tackling which ones: decarbonization goals, storage goals, transportation/distance goals—get conversation to a basis of what we're collectively trying to achieve
 - Even the money doesn't sustain a collaboration unless the team knows what they're trying to achieve together
 - Impacts on jobs are a concern. Projects that can bring any blue collar people to work = more buy in from legislature

Closing Comments Around the Room

- EDA—new integration program; technical assistance type grants fit in with this type of work
- NREL brings tech to market well
- Basic science is important to this discussion. Photosynthesis—could be advanced, in terms of improving efficiency or artificial means. Fuel is 75% energy consumed, 25% electricity
 - Vast potential for better collaboration between industry and academia
 - Unfortunate that there's not a bigger tech presence here today
- One of the whole points is to drive regional collaboration, supposed to be an organic conversation, leave it up to the regions to figure out strengths, etc.
- Always going to be times of day renewables aren't going to be in play—storage is key; energy recovery from wastewater could be a source of storage; can time that sort of thing to with renewables and blend with forecasting
- Role of social science in the effort—changing human behavior could give us quick gains in climate policy

- Front Range and states should position ourselves as leaders in this area—make it known in DC
- Encourage a “systems look” —we create an industry but don't keep it here, like PV—we pushed it but now it is centralized in China
- Think about security—incorporate in the beginning
- As a region, water is one of the most significant resources—think about interconnectivity
- Use urban ecosystems approach to think about how energy efficient we could be
 - We are not well set up to do better with energy—we could bundle issues better for society
 - We're in a bubble here—great if we discuss with community to get unified messaging
 - Lung association—health statistics can help push for it
- Focus on where the need is—three states here have the largest lift to decarbonize under Clean Power Plan
- Clean energy pathway concept: some minimum level of mandate, something like that could be the ante for orgs to be part of regional partnerships
- Real or perceived sense of competition among research institutions, etc. but shared goal: end use utilities, etc. are not in competition with one another, consumers are not in competition. How do we square these things up?
- Think about how valuable models might be—not just emissions and temperatures correlation—show renewables impact on lowering emissions to make better predictive policies
 - Computational models could be useful
- Being able to utilize renewable feedstocks, synthetic biology will be big—going to be able to do a lot
- Students not interested academic but in energy, industry; try to hone our generation of new industries here—create new energy sector here from the ground up

APPENDIX I -- Summary

Session #6: Summary for a Clean Energy Innovation Region

Moderator: Alan Rudolph, Vice President for Research, Colorado State University

- The energy that we got today is going to propel us for what is next. We intend to keep up the momentum. We stand ready to respond if DOE presents the opportunity to our region.
- Bill Ritter is an icon in the field and a national figure. Ritter's questions set the stage for this discussion.
 - Panel: there is a lot of technology—how do we engage with industry in more powerful ways?
 - How do we address models to support revenue generation models that embrace renewables? Broadening landscape so renewables can be more easily integrated
 - Social sciences and behavior are huge—what is it going to take to see adoption and change in our society? How do we integrate diverse voices and make sure everything is done in a socially just fashion?
- Our regional competitive advantage—something he didn't hear was we have distinct generational advantage as well, very young population with millennials. Industry needs to attract this population and seek to exploit it.
- What's ahead?
 - The Collaboratory is a stake in the ground to launch these regional collaborations, ROI is big, and we could consider expanding.
 - Lynn Orr talked about ingredients of successful application—a 501 c3 will be created to meet this requirement.
 - We need to provide bylaws that will create organizational groundwork for the new organization: those are being drafted now.
 - We will be leaving a portal open for additional ideas and comments on the [Regional Summit website](#)
 - Need a placeholder for this very important region and we will immediately following up with a report to DOE.
- Comments from the room
 - DOE has to fund things within the mission. We are looking at technology-neutral things, to put decisions in the hand of the regions to fund those entities and take a systems approach.
 - Need to have action items after this meeting—some kind of next steps to ensure follow up.
 - (University of Utah) Clean energy research in our areas would be a good list to have. It is hard to find them for all the states in our region. It would be useful to have a resource to easily find them. Perhaps the Collaboratory to take that on?
 - Maybe One-day workshops, too? Perhaps Utah could start?

* * * * *