



September 1, 2019

Betsy Markey, Executive Director  
Michelle Hadwiger, Deputy Director & Director of Global Business Development  
Colorado Office of Economic Development and International Trade  
1625 Broadway, Suite 2700  
Denver, CO 80202

Re: Annual Report from the Colorado Energy Research Authority

On behalf of the Board of Directors of the Colorado Energy Research Authority ("the Authority"), in accordance with Section 24-47.5-102(3), Colorado Revised Statutes, I respectfully submit this report regarding the activities of the Authority during calendar year 2018.

The principal statutory purpose of the Authority is to direct the allocation of State funds to support research proposals of the Colorado Energy Research Collaboratory, a research consortium consisting of the Colorado School of Mines, Colorado State University, the University of Colorado Boulder, and the National Renewable Energy Laboratory ("the Collaboratory").

[www.ColoradoCollaboratory.org](http://www.ColoradoCollaboratory.org)

Activity between January 1, 2018 through December 31, 2018 (See **Appendix C** for more detail):

- In June 2018, the Collaboratory hosted a week-long tour of the four Collaboratory entities (CSU, CU, Mines, and NREL) with Principal Director of the U.S. Department of Energy ARPA-E, Chris Fall, and his staff. The week concluded with a meeting between Chris Fall, staff and the Collaboratory leadership. Included in the meeting were venture capital and philanthropic organizations discussing how we could enhance collaboration between the federal government, private industry, research, and VC or philanthropic entities.
- Following the June meeting, at the request of Chris Fall, the Collaboratory successfully hosted an August 2018 ARPA-E Subsurface Energy Roundtable that included over 50 experts from around the nation.
- In July 2018 the Collaboratory hosted a meeting with Breakthrough Energy Ventures, Collaboratory Industry Advisory Committee, researchers awarded Collaboratory projects, University of Wyoming and Denver University to explore future collaborations.
- The four Collaboratory institutions co-hosted the 8<sup>th</sup> annual *21<sup>st</sup> Century Energy Transition Symposium* in downtown Denver on April 1-2, 2019. For the previous seven years Colorado State University had built a recognizable trusted brand of hosting balanced, relevant and solution-driven symposia. The 8<sup>th</sup> annual symposium broaden the theme of "Driving Innovations" into more parts of the state of Colorado and the nation.

Colorado Energy Research Authority  
Annual Report -- September 1, 2019

In January 2016 the Collaboratory released the [economic impact report](#) that covered years 2008 through 2015. The Collaboratory Executive Board reports the following progress and impact between 2016 and 2019:

- A total of 48 proposals were submitted to Collaboratory Executive Board with 29 projects being funded. Energy research topics ranged from biofuels, bioenergy, new materials, oil and gas methane emissions, renewables in wind and solar, efficient buildings, HVAC/Refrigeration, air pollutant sensors, electrified transportation, power systems, wave farms, utilities, fuel cells, and mini-grids. 19 proposals were either turned down by board or were never funded by the original federal agency, therefore cost share was not expended on those 19 proposals.
- Of the 29 projects between 2016 and 2019, all included collaborations between at least 2 out of the 4 Collaboratory entities in order to be awarded. See **Appendix B** for more detail.
  - A total of \$2,078,835 was awarded by Collaboratory Executive Board to the 29 projects in varying amounts between \$25,000 and \$150,000.
  - \$12,995,388 additional money was raised through follow-on funding after Collaboratory awarded the \$2,078,835 money. The \$12million+ is considered leveraged funds.
  - More than 10 provisional or awarded patents were obtained.
  - 62 jobs were created.
  - 105 industry partners involved in the awarded projects.
  - \$2,424,893 was contributed through in-kind contributions on projects.

The measurement of the Collaboratory's effective leveraging of State matching funds is a dynamic process. Since 2008, many research projects that received State funds through the Collaboratory have spawned second, third, and now fourth generations of research, funded by federal, industry, and foundation sources. However, these subsequent generations of research generally receive no additional financial support from the Collaboratory. Between 2008 and 2015, the \$7.96 million of state funding was leveraged into \$96.6 million from industry, DOE, NSF, and other sources to support Collaboratory research projects. This total includes \$53.5 million of first-generation sponsored research projects co-funded by the Collaboratory, and \$43.1 million of sponsored research funding expended from 2008-2015 for next-generation research. Since 2016, the \$12.9 million committed by sponsors and \$2.4 million in in-kind contributions for subsequent generation research from 2016-2019 is not included in the total leveraged research because expenditure of these funds falls outside the 2008-2015 state funding period and the release of the economic impact report January 2017.

The state's investment in the Collaboratory has been extraordinarily productive economically, scientifically and technologically. In **Appendix B** to this report, I summarize the fifteen new grants awarded and paid by the Authority and the Collaboratory in support of research in 2018. In 2018, a total of \$848,678 in disbursements of Authority funding were paid out on behalf of those fifteen projects.

## **As per Collaboratory Authority 2018 annual audit**

### **Financial Highlights**

- The Authority's assets exceeded liabilities by \$860,227 at December 31, 2018. An additional amount of \$566,907 was held at Colorado Office of Economic Development and International Trade that is available as eligible projects are identified.
- Senate Bill 2014-011 was signed by Governor Hickenlooper in May 2014 and \$1 million was transferred on July 1, 2014 and July 1, 2015 to a cash fund held by the Colorado Office of Economic Development that the Authority can apply to use to pay matching grant expenses.
- Expenditures in the amount of \$831,303 were incurred on matching grants and other expenses in 2018.

### **Governmental Activities**

Grant and other expenses were \$831,303 in 2018 as compared to \$107,223 in 2017 and \$392,825 in 2016. Expenses include such costs as annual audit expenditures. The level of grant funding varies from year to year based on several factors.

First, industry membership and related dues paid to Collaboratory centers declined in each year after the recession of 2009. Second, the Collaboratory's commitment to match industry dues ended after three years per center, a policy that encouraged the centers to develop self-sustaining models. Third, another \$2 million was authorized through SB 14-011 through the Governor's Office of Economic Development and International Trade. No other funding from the State of Colorado has been authorized due to recent state budget cuts; however the Collaboratory board members are working on a strategy in which to ask for future cost share funding. Fourth, the availability of federal research funding opportunities that align with the Collaboratory's areas of expertise have declined due to the uncertainty of the federal energy agency's directive such as the Department of Energy. The combination of these factors impact the matching funds disbursed to the Collaboratory centers from earlier years.

## **The Past: An Impressive Record of Successful Investment of State Funding**

In 2006, the General Assembly appropriated \$2 Million per year for three fiscal years, ending in June, 2009 (H.B. 06-1322). These State funds were appropriated to the Authority for allocation to the Collaboratory. The Collaboratory has since then used these funds to attract and supplement funding from federal and private sources.

Under Section 24-47.5-103, as originally enacted in 2006, the Authority was required to demonstrate by June, 2012 that at least \$6 Million in federal grants or contracts for renewable energy research in Colorado had been secured through the Collaboratory programs. In 2012, we reported that the General Assembly's 2006 commitment of \$6 Million had attracted federal and industry funding in excess of \$37 Million, far beyond the \$6 Million baseline requirement.

For the first several years after the Collaboratory was launched in 2007, the Collaboratory's research centers attracted more than 52 industry members and employing state and industry funding to support more than 134 research projects. Beginning in 2010, with the Collaboratory's first U.S. Department of Energy (DOE) sponsored research, federal funding became an increasingly important part of the Collaboratory's portfolio.

The following research centers were funded between 2008 and 2015: CO Center for Biorefining and Biofuels (C2B2); Center for Revolutionary Solar Photoconversion (CRSP); Center for Research and Education in Win (CREW); Carbon Management Center (CMC).

As of January 2016, we proudly reported that the economic impact of Collaboratory operations and research funding in the state of Colorado had resulted in an impressive return on the state's investment. Simply put, **between 2008 and 2015, the Collaboratory investment of almost \$8 million was leveraged to attract more than \$96 million in externally sponsored research, with an associated impact on the local economy of almost \$194 million.** In more specific detail, the total economic impact of \$193.9 million on Colorado constitutes a return of 24:1 on the state's original \$7.96 million investment. [Click here to read the economic impact report.](#)

In most of the previous annual reports from 2008 and 2016 from the Authority, the activities of the Collaboratory centers have dominated the discussion because these centers received most of the state funds and conducted most of the Collaboratory-supported research activities. Each of these centers were managed by a leadership team that includes representatives from all four of the Collaboratory institutions, with one institution serving as the lead. In short, these centers – and their great success to date – have exemplified true collaboration.

## Looking Towards the Future

The Collaboratory leadership has begun strategic and visioning sessions with the goal of creating Collaboratory 2.0 in light of ever changing sources of federal funding and infusing an entrepreneurial and commercialization focus into the twelve year old organization.

- The totality of the original \$10 million in funding from the State between 2007-2019 sunsetted on June 31, 2019. All money was spent out by June 31, 2019. Future

*"The Collaboratory funds were instrumental in allowing the team to meet program cost share requirements and facilitating collaborations between CSU, CU-Boulder, and NREL. Without these multi-disciplinary/multi-institution partnerships it is very likely DOE would not have funded this project. Covering the cost share requirements on federally funded research programs is often a challenge, especially for academic institutions, and can often prevent these institutions from applying to a program they would otherwise be competitive for. The Collaboratory Cost Share Program was able to enhance proposal competitiveness from Colorado institutions by not only fostering collaborations and diversity between Colorado institutions, but also by providing a means for academic institutions to meet often prohibitive cost share levels. We have greatly benefited by the Collaboratory funds and are hopeful State lawmakers can support similar programs in the future."*

**Quote from Project #21 "High Efficiency, Low Cost & Robust Hybrid SOFC/IC Engine Power Generator"** involving CU, Mines, CSU and industry partners

Colorado Energy Research Authority  
Annual Report -- September 1, 2019

discussions focused on Collaboratory 2.0 will include renewed revenue sources that will be utilized for cost share awards and other activity going forward.

- In 2017, the Collaboratory formed an Industry Advisory Committee made up of 16 multi-industry executives. The committee's purpose is to advise the Collaboratory on opportunities for energy-related research and development; advise and advocate for the Collaboratory's strategic initiatives with State of Colorado and National officials; help foster relationships between Collaboratory institutions and industry partners with the goal of enhancing collaboration and partnerships; help create critical partnerships that pair private sector experts with research professionals to bring commercially viable technologies to market, create new products, develop and enhance companies and high-value jobs, grow local economies, while increasing the research capacity of Colorado's research universities in strategic areas; encourage partnerships among universities, federal and state governments, funders, philanthropists and philanthropic organizations, economic developers, workforce developers and the business community in order to strengthen and revitalize university research and speed its translation into innovative products and services; and help merge the discovery-driven culture of the Collaboratory members with the innovation-driven environment of industry for the purposes of facilitating the rapid transfer of knowledge, ideas, and technology to commercialization and productive societal use.
- The Collaboratory continues to host meetings with various venture capital and philanthropic organizations with the goal of diversifying revenue that can be used as cost share and seed grant awards. This includes closely following ARPA-E and federal funding sources. Leadership has presented a three year proposal (UNITE) totaling \$1.25 million to U.S. Department of Energy's Office of Technology Transitions to be used for cost share and matching funds. Decision is pending.
- The Collaboratory will continue to collect actual success stories from researchers and scientists who have received Collaboratory funds. Marketing materials and communication tools will be developed and updated.
- The Collaboratory will increase its visibility with the state legislature by several means including meeting with various elected officials and governmental agency leadership while sharing the successes of the past and emphasizing the Collaboratory's future vision and goals.
- As missions & budgets for federal agencies sponsoring research & innovation changed, in particular those for DOE and NSF, the Collaboratory continues to develop clarity around the federal agency funding opportunities for our Collaboratory researchers to pursue.
- The four Collaboratory entities will once again co-host the 9<sup>th</sup> annual 21<sup>st</sup> Century Energy Transition Symposium in downtown Denver on April 28-29, 2020. There will be 14 different sessions and 50+ speakers from around the country. As we have in the past, we will feature solution-driven research projects funded by the Collaboratory. The theme, "Ideas. Innovate. Impact" will continue the brand and reputation from past symposia.

## A Unique and Outstanding Team Effort

As in any complex issue, it takes building a culture of collaboration with the intent of making a lasting difference. Over the past twelve years, this culture has been nurtured and expanded resulting in projects both big and small. Following the week-long tour from U.S. Department of Energy's ARPA-E Principal Director, Chris Fall, determined that Colorado displayed a unique collaborative culture unlike any state he observed. Consequently it was the reason he influenced the annual ARPA-E Summit to be held in Denver, Colorado July 2019. The Directors of the Colorado Energy Research Authority are grateful for the past support of Colorado's Governors and the Colorado General Assembly, and we are proud that we have exceeded expectations in the effective investment of these State funds. The State's funding has been critical to the Authority's and the Collaboratory's success. It will continue to be critical beyond June 30, 2019 therefore we would seek continued funding to be leveraged with other revenue sources.

Of course, this success would not have been possible without the hard work and exceptional contributions provided by the Collaboratory leadership, the world class researchers and scientists, and the many administrative personnel who support research at the four Collaboratory institutions. They are responsible for the scientific, technological, and economic benefits flowing to the State of Colorado. On behalf of all seven of the Authority Board Directors of the Colorado Energy Research Collaboratory (**See Appendix A**), I offer our thanks and admiration to these many outstanding individuals.

We will be pleased to respond to any questions you may have at this time or in the future.

Sincerely,

DocuSigned by:

*Philip P. DiStefano, Chancellor*

Philip P. DiStefano, Ph.D. Chancellor, University of Colorado Boulder, Chair, Colorado Energy Research Authority

Copies:

Governor Polis

Directors of the Colorado Energy Research Authority

## Appendix A

### 2018 Colorado Energy Research Authority

#### **Board of Directors**

- Philip DiStefano, Ph.D., Chancellor (Chair)  
University of Colorado Boulder
- Anthony Frank, Ph.D., President and Chancellor (Past Chair as of July 1, 2017)  
Colorado State University
- Paul Johnson, Ph.D., President  
Colorado School of Mines
- Martin Keller, Ph.D., Director (Vice-Chair)  
National Renewable Energy Laboratory
- Kathleen Staks, Director  
Colorado Energy Office
- Michelle Hadwiger, Deputy Director  
Colorado Office of Economic Development & International Trade
- Mark Sirangelo, CEO  
Sierra Nevada Space Systems

#### **Executive Board**

- Terri Fiez, Vice Chancellor for Research (Chair)  
University of Colorado Boulder
- Alan Rudolph, Vice President for Research (Past Chair as of July 1, 2017)  
Colorado State University
- Stefanie Tompkins, Vice President of Research and Technology  
Colorado School of Mines
- Peter Green, Deputy Lab Director for Science and Technology  
National Renewable Energy Laboratory

#### **Liaisons to Executive Board**

- Bob McGrath, Executive Director, RASEI, University of Colorado Boulder
- Bryan Willson, Director, Energy Institute, Colorado State University
- Ryan Richards, Associate Vice President for Research, Colorado School of Mines
- Dave Mooney, Executive Director, Institutional Planning, Integration & Development, NREL

#### **Staff**

- Maury Dobbie, Executive Director, Colorado Energy Research Collaboratory

Colorado Energy Research Authority  
Annual Report -- September 1, 2019

## Appendix B

### Collaboratory-approved energy projects between 2016 - 2019

Identifica-tion	Name of Project	PIs and Co-PIs	Amount Awarded
Project #00-2016	Oil & Gas, methane emissions (METEC test site)	Dan Zimmerle (CSU)	\$100,000 (paid in 2016)
Project #0-2017	Diffentiated Methane Sensor Targets for Super Emitters	Garvin Heath (NREL); Dan Cooley (CSU)	\$30,000 (paid in 2017)
Project #1-2017	Advancements in Algal Biomass Yield	Ken Reardon (CSU); Matt Posewitz (Mines)	\$97,647 (paid in 2018)
Project #2-2017	Advanced Module Architecture for Reduced Costs, High durability & Significantly Improved Manufacturability	Kurt Barth (CSU); W.S. Sampath (CSU); Mike Kempe/Ingrid Repins/Sarah Kurtz (NREL); Scott McWilliams-SUNY-Polytechnic PVMC	\$71,086 (paid in 2017)
Project #3-2017	Matrix metalloproteases for biomass processing	Susanta Sarkar (Mines); Yannick Bomble (NREL)	\$0 DECLINED
Project #4-2017	Traineeships in Advanced Biomanufacturing FOA-1790	Ken Reardon (CSU); Robert Baldwin (NREL)	\$0 DECLINED
Project #5-2017	Carbon Coating Basic Metal Oxides with Tailored Facets for Biomass Upgrading	Derek Vardon (NREL); Brian Trewyn (Mines); Ryan Richards (Mines)	\$50,000 (paid in 2018)
Project #6-2017	Characterization & Optimization of Novel Triple-Conducting Oxide Materials for Energy Applications	Ryan O'Hayre (Mines); Steven Harvey (NREL)	\$50,000 (paid in 2018)
Project #7-2017	Ethanol production from lignocellulosic biomass using engineered thermophilic bacteria	Olsen-Dartmouth College; Lynd-Dartmouth College; Amador-Noguez-Univ Wisconsin; Eckert (CU); Sammond (NREL)	\$0 DECLINED
Project #8-2017	Low Cost & Efficient Distributed Power & CO2 Sequestration Reformer-Engine System	Jennifer Wilcox (Mines); Todd Bandhauer (CSU)	\$50,000 (paid in 2018)
Project #9-2017	Energy Modeling and Optimization Framework for Future Smart Building Materials	Paulo Tabares (Mines); Rob Tenent (NREL)	\$0 DECLINED
Project #10-2017	Nano-scale Hybrid Materials for Magnetocaloric Refrigeration	Jose de la Venta (CSU); Meenakshi Singh (Mines)	\$50,000 (paid in 2018)
Project #11-2017	ALARM: A Low-cost Autonomous Robotic Monitor for Air Quality	Jianguo Zhao (CSU); Shantanu Jathar (CSU); Michael Hannigan (CU)	\$0 DECLINED
Project #12-2017	R&D Roadmap for Photovoltaic (PV) Module Recycling Technologies- DOE SETO	Garvin Heath (NREL); Corby Anderson (Mines)	\$0 DECLINED
Project #13-2017	Dynamic Capacitive Wireless Power Transfer System for Electric Vehicles	Khurram Afridi (CU); Jason Quinn (CSU); Aaron Brooker (NREL)	\$50,000 (paid in 2018)
Project #14-2017	Acoustic Tomography of Turbulent Flows Near Wind Turbines	Vladimir Ostashev (CU); Patrick Moriarty (NREL); Juli Lundquist (CU)	\$78,914 (paid in 2018)



Colorado Energy Research Authority  
Annual Report -- September 1, 2019

Project #15-2018	Development of a Multi-fidelity Modeling & Optimization framework for Layout Optimiz-ation of Large-scale Wave Farms in Random Seas	Gaofeng Jia (CSU); Hussam Mahmoud (CSU); Yi-Hsiang Yu (NREL); Nathan Tom (NREL)	\$25,000 (paid in 2018)
Project #16-2018	FASTER-BAT: Fundamental Analysis of Safety Factors in Design Tools for Extreme Rapid-charging BATteries	Pls: Steven DeCaluwe (CSM); Shriram Santhanagopalan (NREL)	\$50,000 – (paid in 2018)
Project #17-2018	Decarbonizing Electricity in an Age of Experimentalist Governance: An Analysis of the Effects of Climate & Energy Policies on Power Plants' CO2 Emissions & Water Footprints	Don Grant (CU); Andrew Jorgenson (Boston College); Wesley Longhofer (Emory); Personnel: William Boyd (CU); Jordan Macknick (NREL); Simone Dominguez (CU)	\$0 DECLINED
Project #18-2018	Center for Bioenergy Innovation (CBI)	Ryan Gill (CU); Carrie Eckert (NREL); Jeff Cameron (CU); Gregg Beckham (NREL)	\$104,944 (paid in 2018)
Project #19-2018	Advancing Insulation Retrofits from Flexible Inexpensive Lucid Materials for Single-Pane Windows	Ivan Smalyukh (CU); Robert Tenent (NREL); Ronggui Yang (CU & NREL); Qingkun Liu and Bohdan Senyuk (CU)	\$150,000 (paid in 2019)
Project #20-2018	Dual-Inductor Hybrid Converter for Direct 48V to sub-1V PoL DC-DC Module (PowerAmerica)	Dragan Maksimovic (CU); Hanh-Phuc Le (CU)	DECLINED
Project #21-2018	High Efficiency, Low Cost & Robust Hybrid SOFC/IC Engine Power Generator	Robert Braun (CSM); Neal Sullivan (Mines); Tyrone Vincent (Mines); Todd Bandhauer (CSU); Dan Olsen (CSU); Bret Windom (CSU); Robert Danforth (Kohler); Bryce Shaffer (Air Squared)	\$75,000 (paid in 2019)
Project #22-2018	An Innovative Computational Platform for Robust and Optimal Operation of Renewable Energy Cities	Wangda Zuo (CU); Yingchen Zhang (NREL)	\$50,000 (paid in 2018)
Project #23-2018	M-POWER (Modern Power Systems Online Workforce Educational Resource) Center	Tom Bradley (CSU); Sid Suryanarayanan (CSU); Ben Kroposki (NREL)	TEAM WAS NOT AWARDED BY FED AGENCY
Project #24-2018	Internet of Robotic Things for Occupant Sensing and Building Heating/Cooling Energy Use Optimization	Paulo Tabares (CSM); Hao Zhang (CSM); Chuck Booten (NREL)	\$42,231 (paid in 2019)
Project #25-2018	Multi-Omics Analysis of Advanced Anaerobic Digestion Processes for Production of High-Value Biofuels	Sybil Sharvelle (CSU); Stephen Decker (NREL). Participants: Corey Broeckling, Ken Reardon, Susan De Long, Kelly Wrighton, Wen Zhu (CSU). Gregg Beckham, Eric Karp, Violetta Sanchez i Nogue (NREL)	\$49,950 (paid in 2018)
Project #26-2018	Food Waste to Bioplastics Precursors via Genetic Engineering of Waste Conversion Microbiomes	Susan De Long (CSU); Ken Reardon (CSU); Katherine Chou (NREL)	TEAM WAS NOT AWARDED BY FED AGENCY

Colorado Energy Research Authority  
Annual Report -- September 1, 2019

Project #27-2018	Road mapping of the Technical Innovation Opportunities for Isolated Mini-Grid Power Systems	E. Ian Baring-Gould (NREL); Samuel Booth (NREL); Bryan Willson (CSU); Dan Zimmerle (CSU); James Cale (CSU)	\$40,000 (paid in 2019)
Project #28-2018	Investigation on Phonon Anharmonicity & its Effect on Phonon-electron Interactions & Optoelectronic Characteristics in Single Crystalline Perovskite Halides	Minhyea Lee (CU); James Neilson (CSU)	\$47,434 (paid in 2018)
Project #29-2018	Low-cost Electronic Nose Sensors for Building Environmental Monitoring	Ed Wolfrum (NREL); Michael Hannigan (CU); Bob Kressin (KS Technologies). Other key: Jason DeGraw (NREL)	TEAM WAS NOT AWARDED BY FED AGENCY
Project #30-2018	Mini-modules Made with Monolithically Integrated All-perovskite Tandems	Mike McGehee (CU); Joseph Berr (NREL); Joseph Luther (NREL); David Moore (NREL); Maikel Van Hest (NREL); Kai Zhu (NREL)	\$142,440 (paid in 2019)
Project #31-2018	Oil and Gas Research Collaboratory (OGRC)	Bud Pope (CU); Greg Rieker (CU) Collaborators: Carl Gelderloos (CU); Garvin Heath (NREL); Dan Zimmerle (CSU)	\$44,400 (paid in 2019)
Project #32-2018	Using Living Quantum Dot-Cell Biohybrid Nano-Organisms to Improve Photon-to-Hydrocarbon Conversion Efficiency and Throughput	Prashant Nagpal (CU); Carrie Eckert (NREL); Anushree Chatterjee (CU)	TEAM WAS NOT AWARDED BY FED AGENCY
Project #33-2018	Artificial Quantum Dot-Cupriavidus Necator Nanobiohybrid Organisms for Waste biomass Conversion into High-value Fuels and Bioplastics	Prashant Nagpal (CU); Carrie Eckert (NREL); Anushree Chatterjee (CU)	TEAM WAS NOT AWARDED BY FED AGENCY
Project #34-2018	Computational Protein Design & Machine Learning to Accelerate Development of Recyclable Lignocellulosic Biomass Deconstruction Enzymes	Tim Whitehead (CU); Joel Kaar (CU); Deanne Sammond (NREL); Shishir Chundawat (Rutgers Univ); Hector Martin (Lawrence Berkeley Nat Lab)	TEAM WAS NOT AWARDED BY FED AGENCY
Project #35-2018	Poly(oxymethylene) Ethers as a High Cetane, Low Sooting Biofuel Blendstock for Use in Medium to Heavy Duty Mixing Controlled Compression Ignition Engines	Bret Windom (CSU); Thomas Foust (NREL); Anthony Marchese (CSU); Jason Quinn (CSU); Ken Reardon (CSU); Nichole Labbe (CU); Lisa Pfefferle (Yale University); Charles McEnally (Yale University)	\$85,000 (paid in 2019)
Project #36-2018	Center for Advancing Natural Gas emissions Technology (CANGET)	Dan Zimmerle (CSU); Kathleen Smits (CSM); Kevin Doran (CU)	\$50,000 (paid in 2018)
Project #37-2018	Linking Volatile Organic Compound Chemistry to Secondary Organic Aerosol Formation from Use of Next-generation Biofuels & Volatile Chemical Products	Shantanu Jathar (CSU); Robert McCormick (NREL); Matthew Thornton (NREL); Brian McDonald (NOAA)	\$44,789 (paid in 2018)

Colorado Energy Research Authority  
Annual Report -- September 1, 2019

Project #38-2018	Food Waste to Bioplastics Precursors via Genetic Engineering of Waste Conversion Microbiomes	Katherine J. Chou (NREL); Susan De Long (CSU); Ken Reardon (CSU)	\$50,000 (paid in 2019)
Project #39-2018	Correlation of Grain Boundary Passivation Chemistry & Electrical Properties for Improving Durability & Performance in Perovskite Solar Cells	Corinne Packard (CSM and NREL); Steven Harvey (NREL); Chun-Sheng Jiang (NREL); Joe Berry (NREL); Brian Gorman (CSM); David Diercks (CSM)	TEAM WAS NOT AWARDED BY FED AGENCY
Project #40-2018	Multi-Objective Deep Reinforcement Learning Control for Energy Efficient & Grid-Interactive Building Operation	Andrey Bernstein (NREL); Gregor Henze (CU); Emiliano Dall'Anese (CU); Peter Graf (NREL); Xin Jin (NREL)	\$100,000 (paid in 2019)
Project #41-2018	Soil Analysis using Networks of Degradable Sensors (SANDS)	Gregory Whiting (CU); Raj Khosla (CSU)	TEAM WAS NOT AWARDED BY FED AGENCY
Project #42-2018	Integrating an Industrial Source and Commercial Algae Farm with Innovative CO2 Transfer Membrane and Improved Strain Technologies	Ken Reardon (CSU); Graham Peers (CSU); David Dandy (CSU); Travis Bailey (CSU); Lieve Laurens (NREL); Deanne Sammond, Ryan Davis (NREL)	\$150,000 (paid in 2019)
Project #43-2018	Environment, Health, and Safety in Oil and Gas Operations	Joost de Gouw (CU); Garvin Heath (NREL); Greg Rieker (CU); Kristy Tiampo (CU); Dan Zimmerle (CSU)	DECLINED
Project #44-2018	Solar Integrated Sustainable and Resilient Data Centers	Wangda Zuo (CU); Kyri Baker (CU); Yingchen Zhang (NREL);	DECLINED
Project #45-2018	Electrolysis & Fuel Cells: Overall Research Electrode Coating Processes	Michael Ulsh (NREL); Svitlana Pylypenko (Mines)	\$150,000 (paid in 2019)
Project #46-2018	Deciphering Metabolism –Development of a Streamlined Meta-bolomic Platform-Kinetic Flux Profiling	Wei Xiong (NREL); Christie Peebles (CSU); Corey Broeckling (CSU); Linxing Yao (CSU); Chao Wu (NREL)	DECLINED

## Appendix C

### Collaboratory-hosted meetings in 2018

**Date: June 11-15, 2018**

**Meeting: ARPA-E staff meeting with all four Collaboratory entities (CSU, CU, Mines, NREL)**

**Location: Colorado State University Powerhouse Energy Campus (Ft. Collins, CO); University of Colorado (Boulder, CO); Colorado School of Mines (Golden, CO); NREL (Golden, CO)**

**Objectives:**

- Chris Fall and staff to meet with actual PIs and ARPA-E teams from the four Collaboratory institutions. Purpose of visit is to learn about future needs and to hear from performers with a focus on good science and commercialization.
- Receive a crash course on "Oil and Gas 101":
  - Meet with oil and gas companies for input on how ARAP-E could be working more closely with the industry (Noble or Anadarko).
  - Chris and staff: to see some wells in Weld or Larimer County (Noble, Anadarko)
- Talk to venture community, philanthropic community, organizational funds, and follow up funders interested in energy, oil and gas.

**Monday June 11: Colorado State University tour**

- METEC methane emissions test site, include Greg Rieker (from CU Boulder) in this tour
- Powerhouse Energy Campus (430 N. College Avenue, Fort Collins, CO 80524)
  - Tour Powerhouse Energy Campus building
  - Meet with Anadarko oil and gas company executives for an Oil & Gas 101 and how ARPA-E can work more closely with the industry
  - University of Wyoming representatives meet in Fort Collins to discuss carbon capture, clean coal and sequestration (Mark Northam and Kipp Coddington)
  - Gili Elkin will share about Israel-Colorado Innovation fund
  - Todd Bandhauer and John McKay ARPA-E projects highlighted (afternoon)

**Tuesday June 12: Anadarko oil/gas facility tour and Colorado School of Mines tour**

- In the morning on the way from Fort Collins to Colorado School of Mines, Chris will visit an Anadarko site in Platteville area (Anadarko point of contact: Angela Zivkovich). Invite CSM's petroleum engineering experts to this meeting to garner their input.
- Noble Energy training facility tour located in Greeley (tentative)
- Tour Colorado School of Mines ARPA-E projects

**Wednesday June 13: National Renewable Energy Lab tour**

- Chris will tour another CSM project in the morning before going to NREL since the oil and gas tour on Tuesday will have utilized some of that day.

**Thursday June 14: University of Colorado Boulder tour**

- University of Colorado Boulder tour will start in the morning
- Collaboratory Authority Board meeting from 9:30-10:30 at CU that involves the Authority Board, Executive Board and liaisons. Chris Fall will meet with Authority Board, Executive Board and Liaisons

**Friday June 15 (morning):** Roundtable with venture capital & philanthropic community at CSU building in downtown Denver.

Invited participants:

- Energy Institute (Bryan Willson, Director)
- Zoma Capital (Ryan Smith and Zach Greenburg)
- Blackhorn Ventures (Trevor Zimmerman, Co-Founder and Managing Partner)
- Colorado Impact Fund (Scott Reich, Senior Associate)
- Factor[E] (Morgan DeFoort, CEO)
- Altira (Dirk McDermott, Managing Partner)
- Breakthrough Ventures (Joel Moxley)
- IN2/Wells Fargo/NREL
- Collaboratory energy liaisons and/or Executive Board (as their schedules permit)

\*\*\*\*\*

**Date: July 27, 2018**

**Meeting: Explore collaborations between VC, philanthropic, governmental, and Collaboratory**

**Location: University of Colorado Boulder, RASEI building (Boulder, CO)**

**Purpose of meeting:** Hear from Breakthrough Energy Ventures where their interests are and where they are focused. Hear from the four Collaboratory partners, University of Wyoming and Denver University. Discuss how we can partner and collaborate in the future.

**Participants:**

- Breakthrough Energy Ventures
  - Eric Toone
  - Joel Moxley
- Collaboratory Executive Board:
  - Terri Fiez, Vice Chancellor for Research and Innovation, University of Colorado Boulder and chair of Collaboratory Executive Board
  - Alan Rudolph, Vice President for Research, Colorado State University and past chair of Collaboratory Executive Board (unable to attend)
  - Stefanie Tompkins, Vice President for Research and Technology Transfer, Colorado School of Mines (unable to attend)
  - Peter Green, Deputy Lab Director for Science and Technology, National Renewable Energy Laboratory (unable to attend)
- Collaboratory energy liaisons:
  - Bob McGrath, Executive Director, Renewable and Sustainable Energy Institute (RASEI), University of Colorado Boulder (unable to attend)
  - Bryan Willson, Executive Director, Energy Institute, Colorado State University
  - Ryan Richards, Professor of Chemistry, Associate Vice President for Research, Colorado School of Mines
  - Dave Mooney, Executive Director, Institutional Planning, Integration and Development, National Renewable Energy Laboratory
- Collaboratory staff: Maury Dobbie, Executive Director
- University of Wyoming (UW): carbon capture and sequestration and reuse; commercialization approach and success stories

- Scott Quillinan, Director of Operations and Communications, School of Energy Resources
- Fred McLaughlin, Senior Research Scientist, Center for Economic Geology Research, School of Energy Resources
- University of Denver (DU): commercialization approach and success stories
  - Martin Katz, Chief Innovation Officer, Executive Director, Project X-ITE
  - Corinne Lengsfeld, Vice Provost for Research and Graduate Education

**AGENDA**

1. Overview of Collaboratory (our partners, our history, who we are, our strengths, our strategy for Collaboratory 2.0, the energy buzz in Colorado, the pipeline the Collaboratory partners are building)
2. Breakthrough Energy Ventures focus and interest areas
3. Highlight of current and past commercialization and summary of commercialization processes from campuses and NREL
  - a. Stories of past companies and current companies in various stages of commercialization
  - b. Developing world commercialization activities and entities:
  - c. Recent ARPA-E projects with commercialization opportunities. Handout of ARPA-E projects at Collaboratory partnering organizations
4. Featured Researchers with other promising technologies
  - a. Colorado State University
  - b. University of Colorado
  - c. Colorado School of Mines
  - d. National Renewable Energy Laboratory
  - e. University of Wyoming
  - f. University of Denver
5. Discussion for next steps
6. Lunch

\*\*\*\*\*

**Date: August 23-24, 2018**

**Meeting: Subsurface Energy Roundtable (roundtable hosted by Collaboratory at the request of Principal Director of ARPA-E Chris Fall)**

**Location: Colorado State University Powerhouse Energy Campus (Ft. Collins, CO)**

**Agenda:**

- |               |   |
|---------------|---|
| 8:30 – 9:00   | Breakfast served  |
| 9:00 – 10:00  | Introductions, charge to the group, DOE and ARPA-E program information, summary of ARPA-E work in oil and gas   |
| 10:00 – 11:00 | <b>Topic 1 – Enhanced Production (Moderated by Fred McLaughlin)</b><br>- Exploration of the topic<br>- Potential white space<br>- Potential PD candidates to lead |

Colorado Energy Research Authority  
Annual Report -- September 1, 2019

11:00 – 12:00	<b>Topic 2 – Environment (Moderated by Tzhai Cath)</b> - Exploration of the topic - Potential white space - Potential PD candidates to lead
12:00 – 12:30	Lunch
12:30 – 1:30	<b>Topic 3 – New Sources (Moderated by Jack Lewnard)</b> - Exploration of the topic - Potential white space - Potential PD candidates to lead
1:30 – 2:30	<b>Topic 4 – New Applications (Moderated by Vik Rao)</b> - Exploration of the topic - Potential white space - Potential PD candidates to lead
2:30 – 3:00	What did we miss? Who did we miss? Lightning round / final thoughts
3:00 – 4:00	Optional tour of Powerhouse Energy Campus
4:00 +	Optional brewery tour and social event in Fort Collins <u>or</u> participants may choose to travel to Golden evening of August 23.

**Friday August 24, 2018:** Optional tour of Colorado School of Mines (CSM) Edgar mining and drilling site in Idaho Springs, Colorado. [Click here for more information](#). The Edgar Experimental Mine is approximately 40 miles west of Denver by Interstate 70 or US6.

#### Participants

1. MEETING HOST: Bryan Willson, Executive Director, Energy Institute, Colorado State University
2. MEETING HOST: Stefanie Tompkins, VP for Resarch & Technology Transfer, Colorado School of Mines
3. DEPARTMENT OF ENERGY'S ARPA-E: Conner Prochaska, Chief of Staff
4. DEPARTMENT OF ENERGY'S ARPA-E: Madhav Acharya, Technology-to-Market Advisor
5. DEPARTMENT of ENERGY'S OFFICE of FOSSIL ENERGY: Elena Melchert, Director of the Upstream Research Division of Oil and Natural Gas
6. DEPARTMENT OF ENERGY'S ARPA-E: Michael Campos, Fellow (geothermal energy, upstream oil & gas, subsurface energy storage)
7. Ryan Richards, Associate Vice President for Research, Colorado School of Mines
8. Bill Eustes, Associate Professor, Petroleum Engineering Dept., Colorado School of Mines (drilling operations, experimental and modeling research expert)
9. Tzahi Cath, Professor, Civil & Environmental Engineering, Colorado School of Mines (produced water expert)
10. Jeff Muhs, Associate Director, Energy Institute, Colorado State University
11. Cindy Beeler, Director EPA Region 8
12. Dirk McDermott, Founder and Managing Partner, Altira

Colorado Energy Research Authority  
Annual Report -- September 1, 2019

13. Scott Quillinan, Director of Operations and Communications, School of Energy Resources, University of Wyoming
14. Fred McLaughlin, Senior Research Scientist, Center for Economic Geology Research, School of Energy Resources, University of Wyoming
15. Kate Faye, Director, Climate Program & Policy, Noble Energy
16. Joel Moxley, Precourt Energy Scholar and Adjunct Professor, Stanford University, Breakthrough Energy Ventures, co-founder of Foro Energy, Biota Technology and Rho AI
17. ShaCelle Manning, Director, Technology Alliances and Ventures, Pioneer Natural Resources
18. Vikram Rao, Executive Director, Research Triangle Energy Consortium at Duke University, former Senior VP and CTO of Halliburton, past-chairman, North Carolina Mining & Energy Commission
19. Bob McGrath, Executive Director, RASEI, University of Colorado
20. Kent Perry, Executive Director, E&P Research, Gas Technology Institute
21. Jack Lewnard, VP of Business Development, Chesapeake Utilities Corporation, former VP and CTO of Gas Technology Institute.
22. Howard Dieter, Director Environmental, Health, Safety and Regulatory for Jonah Energy
23. Dane Boysen, CEO and Founder, Modular Chemical, Former ARPA-E Program Director, former Executive Director of Research Operations at GTI
24. Ramon Gonzalez, founding Director, Advanced Biomanufacturing Initiative (iBIO), Rice University
25. Trevor Zimmerman, Co-founder and Managing Partner, Blackhorn Ventures
26. Stewart Brazil, Chief Scientist, Baker Hughes
27. Cal Cooper, Manager of Special Projects, Apache Corporation
28. Oleg Mikhailov, Partner and Managing Director, Boston Consulting Group
29. Jamie Beard, Assistant Director, Blackstone Launchpad, Austin Technology Incubator
30. Robin Rogers, President, 525 Solutions and research professor, The University of Alabama
31. Kate Young, Geothermal Program Manager, National Renewable Energy Laboratory
32. Ned Harvey, Managing Director Industry Program, Rocky Mountain Institute
33. POINT OF CONTACT: Maury Dobbie, Executive Director, Colorado Energy Research Collaboratory