



Water Energy Nexus Interdisciplinary Research Theme

2018 Year End Report

2018 Water Energy Nexus IRT Annual Report

IRT Scope and Mission

The interactions between water, energy, and associated systems have profound impacts on our society. As such, the nexus of water and energy is, and will continue to be, one of the world's leading long-term technical challenges. The Water-Energy Nexus Interdisciplinary Research Theme (IRT) aims to bring together researchers from different disciplines to address the pressing challenges surrounding water, energy, and associated systems such as food, land, air quality, and climate.

Research teams consisting of faculty and students across engineering departments have fostered interdisciplinary collaboration on large scale water-energy research projects to raise visibility and strengthen our leadership and accelerate our societal impact. Research has focused in a number of areas including water and air pollution concerns around unconventional energy exploration, the interplay of water and energy in the urban setting including future cities, balancing water resources needs to minimize energy use, and optimize water use in municipal, energy and agriculture sectors, low energy treatment technologies for water sustainability, and energy storage.

The IRT provides a unique interdisciplinary training program for engineering students to enable them to become future leaders and will continue to provide leadership and support for stakeholders to build upon each other's strengths to achieve major accomplishments beyond individual successes.

Most Significant IRT Accomplishments in 2019

- Team formed to pursue IUCRC on Environmental Health & Safety with oil and gas industry. Discussions with Chevron on potential partnerships between Reiker/Hannigan/Chevron on methane leak detection. (Reiker, Linden)
- Jennifer Cha as Co-PI, NSF Soft Materials Research Center (MRSEC) and Co-PI, GAANN Program in Materials for Energy and Sustainability
- CU Boulder IRT faculty part of 3 separate National Lab-led teams pursuing the \$100M 5 year DOE Energy-Water Desalination HUB
- Linden elected 2018-19 President-Elect of Association of Environmental Engineering and Science Professors – and President in 2019-2020.
- Pellegrino Director of North American Membrane Society

Seed Grant Summary

- Rapid and Novel Agglomeration Process in the Water-Energy Nexus (PIs: Rob Davis, Sherri Cook)
 - This seed grant has resulted in a new collaboration between the PI and Co-PI and led to an enhanced collaboration between the PI and Professor Kevin Galvin at the University of Newcastle, Australia - A proposal for \$110,000 for follow-on funding is currently under review at ACS-PRF.
- Fracking soils: towards an engineered delivery method for environmental remediation and soil modification (PIs: Yida Zhang, Joe Ryan)
 - This work has gotten state and local level media coverage
 - Developed capability of performing coupled CFD-DEM simulation where the effect of fluid injection rate and sample preparation method on the fracturing pattern has been investigated, and reviewed new variables for granular fingering problems.
- Toward water and energy security via improved characterization of reservoir sedimentation (PIs: Ben Livneh, Joe Kasprzyk)
 - The seed grant resulted in a new collaboration with CIRES researchers, supported an NSF GRFP application and contributed to MS thesis of student.
- Tradeoffs of Alternate Water Resources for Thermoelectric Power Plant Cooling (PIs: Joe Kasprzyk, Ben Livneh, Kyri Baker, Lisa Stillwell, Dilling)
 - Kasprzyk started working with Prof. Ashlynn Stillwell from the University of Illinois Urbana-Champaign on a framework for assessing the effects of reclaimed water usage on downstream stakeholders – through this collaborative team, we will be able to pursue funding with the National Science Foundation's Environmental Sustainability Program.
- Robust Membrane for Treatment of Flue-gas Desulfurization (FGD) Waste Water (PIs: Yifu Ding, Jason Ren, Rong Long)
 - The seed grant has resulted in a new collaboration with NIST Boulder; One graduate student developed valuable skills/expertise in the membrane fabrications; The team submitted a \$3 M proposal to DOE in 2018.
- Application of Fourier Transform Ion Cyclotron Resonance Mass Spectrometry (FT-ICR MS) for Environmental Sample Analysis: Development of Internal Expertise (PIs: Fernando Rosario-Ortiz, Jason Ren, Rong Long)
 - New Grant from Chevron to use FT-ICR MS to analyze hydrocarbon degradation in contaminated sites Manuscripts in preparation on revealing the daughter products generated from bioelectrochemical hydrocarbon degradation Discussions on new proposals are in progress – NSF, EPA, Chevron
- Reducing Water Consumption via Free Market Renewable Integration (PIs: Kyri Baker, Rafael Frongillo)
 - This seed grant has resulted in a new collaboration between the PIs in Civil Engineering and Computer Science. An accepted paper on this topic will be presented at the Architectural Engineering Institute Conference next year.
- Mixed-Conductor Cascade Electrodes for High Density Energy Storage in Li2O2 (PIs: Adam Holewinski, Sehee Lee)

- This seed grant has thus far resulted in one proposal submission (ARPA-E \$2M, not funded), and a second proposal in preparation (DOE, ~\$750k), which will include a new collaboration (internal) that we were able to initiate with seed-grant-enabled data.
- Integrated water, energy, and emissions trajectories and tradeoffs for the U.S. (PIs: Sherri Cook, Jana Milford)
 - This seed grant has resulted in a new collaboration, conference presentation and proceeding, and provided preliminary data for a proposal to be submitted in 2019.
- Enhanced UV-LED Water Purification Using Magnetically Retrievable Nano Photo-catalysts (PIs: Al Weimer, Karl Linden)
 - Materials synthesized and evaluated for efficacy in water disinfection, but further work is needed for concept validation.
- Upcycling slags for passive purification of wastewater & landfill biogas: optimization and mechanistic studies for the sustainable reuse of these promising industrial byproducts (PI: Mark Hernandez)
 - Executed a 9-month pilot scale anaerobic digestion project at the Boulder Wastewater treatment plant demonstrating the practical feasibility for the beneficial reuse of steel slags for the sequestration of macronutrients (S and P) and the cost-effective purification of anaerobic digester biogas.
- Nanoscale Photocatalysts for Oxidative Polymerization of Aromatics for Simultaneous Wastewater Pretreatment and Hydrogen Production (PIs: Jennifer Cha, Andrew Goodwin)
 - Supported 1 graduate student (now at NREL) for 1 summer month stipend, opening up new collaborations with Niels Damrauer and Gordana Dukovic in Chemistry. Two grants were submitted to DOE and NSF in November 2018. The DOE grant was a full proposal submitted with the support of the program officers.
- Advanced catalysts for efficient hydrogen peroxide synthesis (PIs: Will Medlin and Charles Musgrave)
 - Supported 1 PhD student for one month, prepared catalysts targeted for H₂O₂ synthesis reactions, and have sent those to a collaborator for evaluation. Proposal pending related to this area (NSF, \$300K to CU).
- PEGI: Peroxide Enhanced Germicidal Irradiation of building HVAC systems for bioaerosol disinfection, energy conservation and condensate reclamation (PI: Mark Hernandez)
 - Successful lab scale demonstration of trace hydrogen peroxide vapor irradiated with UVLEDs in mock HVAC heat transfer equipment for reclamation and reuse of HVAC system concentrate. This demonstration has significant implications for reducing indoor bioaerosol exposures while reducing building energy and water use.

Next Steps and Anticipated Milestones

This year there are plans for Seed grants and course buyouts to stimulate the agglomeration of teams and activities toward the goal of positioning ourselves for large grant opportunities in the areas of our strengths.

Three seed grants are planned for amounts of up to \$50K each. These grants will be given to teams to support activities around an area of identified opportunity. Last year we identified

areas of research that were common among the IRT and aligned these with potential opportunities that may come up over the next 2 year via NSF, DOE and other agencies, along with recent grand challenges in water announced by DOE.

In addition to Seed grants, up to 3 course buyouts will be offered to faculty willing to lead efforts toward submission of a large proposal. This will include development of research White Papers in key identified areas that will serve as items to shop around to agencies and program managers, as well and consolidate research teams at CU. These buyouts will likely be aligned with the Seed grants but may also differ depending on opportunities identified.

The IRT will also leverage funds to support recruitment of graduate students and post-docs in the water-energy area. These students will be IRT fellows and will participate in activities in the IRT and in development of White Papers.

IRT Performance Metrics

Industry Collaboration

New external collaborations

- Visit Oak Ridge National Laboratory to discuss collaboration on their smart city initiative (Zuo)
- Shell Oil (Solar-Thermal Processing) (Weimer)
- Aerosol Devices Inc (Fort Collins, Colorado) (Hernandez)
- DetectionTek Holdings LLC (Boulder, Colorado) (Hernandez)
- Bureau of Reclamation- PI Zhang presented seed grant results to BOR and they expressed general interest in future collaboration that is under discussion. (Zhang)
- Team formed to pursue IUCRC on Environmental Health & Safety with oil and gas industry. Discussions with Chevron on potential partnerships between Reiker/Hannigan/Chevron on methane leak detection. (Reiker, Linden)
- Bruno Azeredo (Arizona State University); Sandia National Labs (Ding)
- Continuing collaboration with Chevron on the analysis of hydrocarbon degradation in soils. (Rosario-Ortiz)
- UV-LED technology for water disinfection companies Crystal IS and Aquisense collaboration with Linden Lab on low energy distributed water disinfection (Linden)

Technology transfer, IP generation, and start-ups

- Hernandez, M., Bilgin, A.A. and Grubb D.G. Sequestration of macronutrients from anaerobic wastewater treatment with iron and steelmaking residuals. PCT WO 16998 A1. Published September 2018. (Hernandez)
- Hernandez, M., Abu-Dalo, Khanna, G, and Quick, A. Metal Removal System and Method, US Patent # 10,106,437, Issued October 2018 (Hernandez)
- U.S. Patent Application No. 14/426,670: FILTRATION MEMBRANES WITH NANOSCALE PATTERNS has been allowed by the USPTO (Pellegrino)
- Two patents were allowed related to our frequency comb-based methane detection system. We spun out LongPath Technologies, Inc. in 2018 to commercialize the system. (Reiker)

Reputation

Faculty in national leadership positions

- The National Academy of Science, Engineering and Medicine, committee member: Urbanization and Slums: New Transmission Pathways of Infectious Diseases in the Built Environment (Hernandez)
- Linden elected 2018-19 President-Elect of Association of Environmental Engineering and Science Professors – will be President in 2019-2020. (Linden)
- Director of North American Membrane Society (Pellegrino)
- Peer reviewer for progress of DOE's U.S./China CERC-WET (Clean Energy Research Center for Water-Energy Technology) Research collaborative (<https://cerc-wet.berkeley.edu/>) (Zagona)
- Peer reviewed for DOE, NSF and >100 manuscripts for journals (Holewinski)
- NREL Appointments (Holewinski and Lee)
- Peer Reviewer for multiple NSF, NIH proposals. (Cha)
- I was an external reviewer for the water-energy-food nexus center call SusWEF that is based at the University of Puerto Rico. (Medlin)
- PI Kasprzyk is the deputy chair of the Water and Society technical committee of the Hydrology section of the American Geophysical Union. (Kasprzyk)
- Members of editorial advisory boards for EST (FRO) and Environmental Science: Water Research & Technology (JR). Associate Editor for JAWWA Water Science (FRO)

National Press for IRTs

- [CU Boulder-led team melds oil and gas research, public policy \(Joe Ryan/Karl Linden\) – Boulder Daily Camera, 10/13/18](#)
- [Invisible Leaks: Where “Clean” Natural Gas Falls Short \(Joe Ryan/AirWaterGas\) – InsideEnergy, 3/28/18](#)
- [Living With Uncertainty: Is Oil And Gas Bad For Your Health? \(AirWaterGas\) – 5/19/18](#)
- [High schoolers worked with engineering students from CU to test the air quality of their schools \(AirWaterGas\) – Greeley Tribune, 3/22/18](#)
- [CU Boulder researcher sees inspiration for new turbine technology in nature \(Lucy Pao\) – Boulder Daily Camera, 10/12/18](#)

Recognition by peer institutions

- Invitation to present lectures on seed grant work at Stanford University and the University of Canterbury (Davis)
- Texas Tech University (Weimer)

- Montana State University (Weimer)
- Shell Oil Company (Weimer)
- University of Hong Kong, High Density Urban Building Exposure Assessment (Hernandez)
- University of Witwatersrand, South Africa, Reclamation of Mining Runoff (Hernandez)
- An accepted paper will be presented at the 2019 Architectural Engineering Institute Conference. (Baker)
- American Society of Civil Engineers, North Coast Branch, "Oil and Gas Development and Groundwater Quality in Colorado's Denver-Julesburg Basin," Eureka, California, November 8, 2018. (Ryan)
- Humboldt State University, Department of Environmental Resources Engineering, "The Road to Jericho: Abandoned Mines, the Clean Water Act, and Environmental Good Samaritans," November 2, 2018. (Ryan)
- Dawson School, "Oil and Gas Development: Effects on Front Range Air and Water," community presentation with Lisa McKenzie and Jana Milford, Boulder, Colorado, April 26, 2018. (Ryan)
- Paonia Science Symposium, "Oil and Gas, Air and Water," community presentation at high school science symposium, Paonia Colorado, April 11, 2018. (Ryan)
- Colorado Municipal League, "AirWaterGas: Who We Are and How We Can Help Municipalities with Oil and Gas Development," webinar with Michael Hannigan, Tanya Heikkila, and Kathryn Mutz, Denver, Colorado, April 9, 2018. (Ryan)
- Rocky Mountain Association of Environmental Professionals, "Investigating the Effects of Oil and Gas Development on Water Quality in Colorado," Golden, Colorado, February 22, 2018. (Ryan)
- Escuela Bilingüe Pioneer Parent-Teacher Association, "Effects of Oil and Gas Development on Groundwater Quality in Colorado," community meeting with Stephanie Malin and Lisa McKenzie, Lafayette, Colorado, January 8, 2018. (Ryan)
- Multiple invited lectures at national conferences and departments, including International Institute for Nanotechnology, Northwestern University. (Cha)
- Invited lectures at ETH-Zurich, Ohio State, University of Pittsburgh, Virginia Tech University, and University of Delaware. (Medlin)
- Invited Departmental Seminar at University of Wyoming. Invited talk at ACS (American Chemical Society) March meeting 2019 (Orlando) in jointed ACS-NAMS(North American Membrane Society) symposium. Organizing two symposiums at 2019 ACS Fall meeting (San Diego) and 2019 Fall MRS meeting (Boston), both of which are on membrane research in addressing water/energy nexus. (Ding)

Publications and conference presentations

- Keshavarzmohammadian, A.; Milford, J.B; Cook, S.M.† Impacts of Power Generation Technology Choices on Life Cycle Water Consumption. Proceedings of the Life Cycle Assessment XVIII Conference, 4 pgs, Fort Collins, CO, September, 2018. (Sherri Cook and Jana Milford)

- Keshavarzmohammadian, A.; Milford, J.B; Cook, S.M.† Impacts of Future Scenarios for Natural Gas Production and Use on Life Cycle Water Consumption. Life Cycle Assessment XVIII, Fort Collins, CO, September, 2018. (Sherri Cook and Jana Milford)
- Presentation at International Society for Water Solutions' Industrial Water Use and Reuse Workshop, Nov 15-16, 2018 in San Antonio, TX and participated in AIChE RAPID Workshop focused on DOE Water Security Grand Challenge (Pellegrino)
- Paper published: Particle collection by permeable drops, Davis, RH and Zinchenko, AZ, Physical Review Fluids 3: 113601 (2018) (Davis)
- Paper presented: Rapid particle agglomeration using permeable films, presented by RH Davis at 2018 Annual AIChE Meeting (Davis)
- Paper presented: Particle collection by emulsion drops with permeable interfaces, presented by RH Davis at 2018 ACS Colloids and Surface Science Symposium (Davis)
- Livneh MT Thesis forthcoming and journal article development to follow thereafter (Livneh)
- Hoskins, A.L., S.L. Millican, C.E. Czernik, J.C. Netter, T.J. Wendelin, C.B. Musgrave, and A.W. Weimer, "Continuous on-sun solar thermochemical hydrogen production via an isothermal redox cycle," Applied Energy (submitted, 2018) (Weimer)
- Rowe, S.C., I. Hischer, A.W. Palumbo, B.A. Chubukov, M. A. Wallace, R. Viger, A. Lewandowski, D.E. Clough and A.W. Weimer., "Nowcasting, Predictive Control, and Feedback Control for Temperature Regulation in a Novel Hybrid Solar-Electric Reactor for Continuous Solar-Thermal Chemical Processing," Solar Energy, 174, 474-488 (2018) (Weimer)
- Arifin, D. and A.W. Weimer, "Kinetics and Mechanism of Solar-thermochemical H₂ and CO Production by Oxidation of Reduced CeO₂," Solar Energy, 160, 178-185 (2018). Rogers J.D., Thurman E.M., Ferrer I., Rosenblum J.S., Evans M.V., Mouser P.J., and Ryan J.N., 2018. Degradation of polyethylene glycols and polypropylene glycols in microcosms simulating a spill of produced water in shallow groundwater. Environmental Science: Processes and Impacts, doi:10.1039/C8EM00291F. (Weimer)
- Entekin S., Trainor A., Saiers J., Patterson L., Maloney K., Fargione J., Kiesecker J., Baruch-Mordo S., Konschnik K., Wiseman H., Nicot J.-P., and Ryan J.N., 2018. Water stress from high-volume hydraulic fracturing potentially threatens aquatic biodiversity and ecosystem services in Arkansas, U.S.A. Environmental Science & Technology 52(4), 2349–2358; doi: 10.1021/acs.est.7b03304. (Ryan)
- Lackey G., Rajaram H., Chauhan D., Sherwood O.A., and Ryan J.N., 2019. Stray gas migration for oil and gas wells in Colorado and New Mexico. To be presented at the National Groundwater Association Groundwater and Oil and Gas Development: Improved Management Practices for Groundwater Protection and Water Supply, March 4-5, 2019, San Antonio, Texas. (Ryan)
- Lackey G., Rajaram H., Chauhan D., Sherwood O.A., and Ryan J.N., 2018. Surface casing pressure development and the risk of groundwater contamination in Colorado and New Mexico. Presented at the Resources for Future Generations Conference, Vancouver, British Columbia, Canada, June 16-18, 2018. (Ryan)
- Lackey G., Rajaram H., Chauhan D., Sherwood O.A., and Ryan J.N., 2018. Using a convolutional neural network and a collaborative web application to aggregate data from scanned well

integrity reports in Colorado and New Mexico. Presented at the Annual Shale Network Workshop, State College, Pennsylvania, May 17-18, 2018. (Ryan)

- Gevaudan, J. P., Caicedo-Ramirez, A., Hernandez, M. and Srubar, W. (2018) Copper and Cobalt Microadditives Improve the Acid Resistance of Alkali-Activated Cements, Cement and Concrete Research, 115:327 (Hernandez)
- Grubb, D., Landers, D., Almeida Guerra, P., Miller, B., Bilgin, A., and Hernandez, M. ,(2018) Sugarcane Bagasse as a Microbial Host Media for the Passive Treatment of Acid Mine Drainage, ASCE J of Environmental Engineering, 144:10 (Hernandez)
- Abu-Dalo, R.A., AbuDalo, M.A., and Hernandez, M., (2018) Stability of Benzotriazole Derivatives with Free Cu, Zn, Co and Metal-Containing Enzymes: Binding and Interaction of Methylbenzotriazoles with Superoxide Dismutase and Vitamin B12. IOP Materials Science and Engineering, 305:012024 (Hernandez)
- Ababneh, A. N., Abu-Dalo, M.A., Horn, C. and Hernandez, M. , (2018) Polarographic Determination of Benzotriazoles and their Sorption Behavior on Granular Activated Carbon, Int. J. Environmental Science and Technology, doi.org/10.1007/s13762-018-1706-y (Hernandez)
- Abu-Dalo, M.A., O'Brien, I., and Hernandez, M. (2018) Effects of Substitutions on the Biodegradation Potential of Benzotriazole Derivatives, IOP Materials Science and Engineering, 305:012020 (Hernandez)
- Justo-Reinoso, I., Srubar, W.V., Caicedo-Ramirez, A., Hernandez, M., (2018) Fine aggregate substitution by granular activated carbon can improve physical and mechanical properties of cement mortars, Construction and Building Materials, 164 750-759. (Hernandez)
- One publication is under preparation. The paper will be submitted to petroleum engineering related journals. (Zhang)
- Nicholas Long, Gregor Henze, Justus von Rhein "A Framework for Reduced Order Building Modeling for Fifth- Generation District Heating and Cooling Networks." Energy; submitted November 27, 2018. (Henze)
- Justus von Rhein, Gregor Henze, Nicholas Long, Yangyang Fu „Development of a Topology Analysis Tool for Fifth-Generation District Heating and Cooling Networks.“ Energy Conversion and Management; submitted November 27, 2018. (Henze)
- The specific technology from our seed project has not been reported on yet, but the underlying catalyst synthesis technique was described in the article: Nature Catalysis (2018), 1, 148-155. (Medlin)
- Purcell, P, ZA Barker, JR Kasprzyk, AS Stillwell. "Linking reclaimed water consumption with quantitative downstream flow impacts" In Review With Co-Authors. Journal of Water Resources Planning and Management
- Kasprzyk, JR*, AS Stillwell "Tradeoffs of Alternate Water Resources for Thermoelectric Power Plant Cooling" Conference Presentation at ASCE Environmental Water Resources Institute, Minneapolis, MN, June 2018
- Purcell, B*, ZA Barker, JR Kasprzyk, AS Stillwell "Scenario analysis of downstream flow impacts from reclaimed water consumption in two distinct regions" Poster Presentation at Fall Meeting of American Geophysical Union 2018

- Hull, N.M., Rosenblum, J.S., Robertson, C.E., Harris, J.K., Linden, K.G. (2018) Succession of toxicity and microbiota in hydraulic fracturing flowback and produced water in the Denver–Julesburg Basin. *Science of The Total Environment* 644, 183-192
- Jones, C.H., Shilling, E.G., Linden, K.G., Cook, S.M. (2018) Life Cycle Environmental Impacts of Disinfection Technologies Used in Small Drinking Water Systems. *Environmental Science & Technology* 52 (5), 2998-3007
- Ulliman, S.L., Miklos, D.B., Hübner, U., Drewes, J.E., Linden K.G. (2018) Improving UV/H₂O₂ performance following tertiary treatment of municipal wastewater. *Environmental Science: Water Research & Technology* 4 (9), 1321-1330

Proposals and Projects

Multi-department proposals/projects (> \$1M)

- Submitted \$2.4M multi-department/institution DOE proposal: Hybrid Absorption-Membrane Processes Enabling Reduced CO₂ Cost (HAMPER CO₂) (Pellegrino)
- 2018 ARPA-E Open, \$2M, (not awarded) (Holewinski)
- NSF Industrial Innovation and Partnerships, Fluorescence Coupled Condensation Capture, Phase II, (Hernandez with Aerosol Devices, Inc., Fort Collins)
- State of Colorado AIA, Corrosion Resistant Concrete Admixtures, (Hernandez with Forterra, Inc., Denver)
- Possible submission of Graduate Assistance in Areas of National Need proposal when a future RFP is issued, approximate total \$1.1 M over three years (Davis)
- Planning grant obtained from the Colorado Energy Research Collaboratory to help develop the Operational Renegade Gas (ORG) group into an IUCRC proposal team. Planned proposal submission in 2019 led by Joost De Gouw. (Reiker)
- Co-PI, NSF Soft Materials Research Center (MRSEC). Co-PI, GAANN Program in Materials for Energy and Sustainability (Cha)
- Hybrid adsorption-membrane processes for CO₂ capture (HAMPER CO₂), \$3M submitted to DOE in Nov. 2018 (Ding)

Center-scale proposals/projects (> \$10M)

- Member of DRINC Team submittal for DE-FOA-0001905: Energy-Water Desalination Hub issued Dec 12, 2018 (Pellegrino)
- NSF ERC with Baylor, Arizona State, Michigan State, and Oregon State - Baylor lead - Solar thermal processing (Weimer)
- My collaborator is preparing a \$50 M AUD Centre of Excellence proposal to the Australian Research Council, for which I am an international participant (Davis)
- Center for Harnessing Energy-Water Interface Environments (CHEWIE), PI: Dan Schwartz (Chemical Engineering), EFRC proposal submitted in July 2018 (declined). (Ding)
- Member of NAWI team led by LBNL/NREL/ORNL pursuing the DOE Energy-Water Desalination HUB \$20M/yr (Linden is CU team lead)

- Part of a team, led by Sandia National Lab, in preparation to respond to a call by DOE on Desalination Hub. \$ 20M/year for 5 years, concept paper due Feb 2019. (Ding)

APPENDIX

IRT Members

Last Name	First Name	Dept	Email
Afridi	Khurram	ECEE	khurram.afridi@colorado.edu
Baker	Kyri	CEAE	Kyri.Baker@colorado.edu
Bortz	David	AM	dmbortz@colorado.edu
Cha	Jennifer	CBE	jennifer.cha@colorado.edu
Chen	Zudong	ECEE	Xudong.Chen@Colorado.edu
Cook	Sherri	CEAE	sherri.cook@colorado.edu

Davis	Rob	ChBE	robert.davis@colorado.edu
Dilling	Lisa	CEAE	lisa.dilling@colorado.edu
Ding	Yifu	ME	Yifu.Ding@colorado.edu
Dixon	Cory	AES	cory.dixon@colorado.edu
Fierer	Noah	EEB	noah.fierer@colorado.edu
Frew	Eric	AE	frew@colorado.edu
Frongillo	Rafel	CS	raf@colorado.edu
Gasiewski	Al	ECEE	Al.Gasiewski@colorado.edu
Heath	Garvin	NREL	garvin.heath@nrel.gov
Henze	Gregor	CEAE	gregor.henze@colorado.edu
Hernandez	Mark	CEAE	Mark.Hernandez@colorado.edu
Herzfeld	Ute	ECEE	Ute.Herzfeld@colorado.edu
Holewinski	Adam	CBE	adam.holewinski@colorado.edu
Huang	Shu-Wei	ECEE	ShuWei.Huang@Colorado.edu
Kasprzyk	Joseph	CEAE	joseph.kasprzyk@colorado.edu
Keplinger	Christoph	ME	Christoph.Keplinger@colorado.edu
Korak	Julie	CEAE	Julie.Korak@colorado.edu
Labbe	Nicole	ME	nicole.labbe@colorado.edu
Le	Hanh-Phuc	ECEE	hanhphuc@colorado.edu
Lee	Sehee	ME	Sehee.Lee@colorado.edu
Linden	Karl	CEAE	Karl.Linden@Colorado.edu
Livneh	Ben	CEAE	ben.livneh@colorado.edu
Long	Rong	ME	Rong.Long@colorado.edu
Lv	Qin	CS	qin.lv@colorado.edu
Medlin	Will	CBE	will.medlin@colorado.edu
Milford	Jana	ME	Jana.Milford@colorado.edu
Pao	Lucy	ECEE	Lucy.Pao@colorado.edu
Pellegrino	John	ME	John.Pellegrino@colorado.edu
Pourajmadian	Fatemah	CEAE	fatemeh.pourahmadian@colorado.edu
Raj	Rishi	ME	Rishi.Raj@colorado.edu
Rieker	Greg	ME	Greg.Rieker@colorado.edu
Rosario-Ortiz	Fernando	CEAE	Fernando.Rosario@colorado.edu
Ryan	Joe	CEAE	Joseph.Ryan@colorado.edu
Schwartz	Daniel	ChBE	daniel.schwartz@colorado.edu
Shang	Li	ECEE	Li.Shang@colorado.edu
Silverstein	JoAnn	CEAE	joann.silverstein@colorado.edu
Summers	Scott	CEAE	R.Summers@colorado.edu
Thomas	Evan	CEAE	Ethomas@colorado.edu
Vance	Marina	ME	marina.vance@colorado.edu

Walker	Michael	CEAE	Mike.Walker@colorado.edu
Weimer	Al	CBE	alan.weimer@colorado.edu
Wham	Brad	CEAE	Brad.Wham@Colorado.edu
Yang	Ronggui	ME	Ronggui.Yang@colorado.edu
Zagona	Edith	CEAE	zagona@colorado.edu
Zhai	John	CEAE	John.Zhai@colorado.edu
Zhang	Yida	CEAE	Yida.Zhang@colorado.edu
Zuo	Wangda	CEAE	Wangda.Zuo@colorado.edu