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Retreat

June 1, 2022
Princeton Marriott at Forrestal

Poster Abstracts

andlinger center for energy+the environment

PRINCETON UNIVERSITY

Abstracts by Core Research Area

built environment, transportation + infrastructure

fuels + chemicals

electricity production, transmission + storage

environmental sensing + remediation

decision + behavioral science, policy + economics

environmental + climate science

Holly Caggiano[1]

Distinguished Postdoctoral Fellow
Principal Investigators: Elke Weber[1,2,3], Chris Greig[1]

[1] Andlinger Center for Energy and the Environment
[2] Department of Psychology
[3] School of Public and International Affairs

Dimensions of Public Support for Low-Carbon Energy Infrastructure Projects

Abstract

Renewable energy infrastructure must be deployed at an unprecedented speed and scale to mitigate catastrophic climate impacts, requiring sustained community support. We evaluate the impact of 24 different social, political, and aesthetic features of energy projects on support for project development in a demographically representative sample of Pennsylvania residents. We find that creation of permanent, union-scale wage jobs, low impact on wildlife habitats, and cooperative community ownership increases support for energy projects. Respondents prefer solar and onshore wind projects to natural gas with carbon capture and storage, and support decreases for nuclear projects and projects owned by overseas companies.

Bio

As an Andlinger Center Distinguished Postdoctoral Fellow working with the Behavioral Science for Policy Lab, Caggiano's interdisciplinary research explores social dimensions of the renewable energy transition in the U.S. Her work investigates how diverse stakeholder groups form coalitions to advocate for energy systems change. This work connects patterns across decision-making scales, exploring the ways individual decision-making influences collective action and how collective action disrupts existing relations of power in local energy politics. She earned her Ph.D. from the Edward J. Bloustein School of Planning and Public Policy at Rutgers University.

Fangwei Cheng[1]

Postdoctoral Research Associate
Principal Investigator: Eric Larson[1]

[1] Andlinger Center for Energy and the Environment

The Value of Biomass in Transition to Net-Zero Carbon Emissions Economies

Abstract

Biomass with carbon capture and storage (CCS) play critical roles in achieving economy-wide net-zero greenhouse gas emissions because they provide carbon-negative energy carriers. Here we present lifecycle carbon and cost assessments to provide insights into the environmental and economic performance of biomass-derived fuels (e.g., H_2, synthetic methane, and Fischer-Tropsch liquid), and compare the performance of biomass-derived fuels against other routes using natural gas or renewable electricity. We find fuel production pathways starting from biomass with CCS have the highest carbon mitigation potentials among all feedstock pathways. They also have the lowest production costs beyond certain carbon price thresholds.

Bio

Cheng’s research interests include energy system modeling, life cycle assessment, and techno-economic assessment of low and negative carbon-emission technologies. She is currently part of both the Zero carbon Energy systems Research and Optimization (ZERO) Lab and the Energy Systems Analysis Group. She obtained a bachelor’s degree in chemical engineering from the Wuhan Institute of Technology, an M.S. in chemical engineering from the University of Missouri, and a Ph.D. in civil engineering from the University of Virginia. For her Ph.D. dissertation, she integrated machine learning, life cycle assessment, and techno-economic assessment to evaluate different negative-emission technologies.

Loïc De Weerdt[1]

Postdoctoral Research Associate
Principal Investigators: Chris Greig[1], Eric D. Larson[1], Carlos Oliveira[2]

[1] Andlinger Center for Energy and the Environment
[2] Lisbon School of Economics and Management

Investment in Net-Zero Electricity Under Price Uncertainty

Abstract
We study decision-making to invest in net-zero technologies for electricity generation using a real option approach. Specifically, we study how a private electricity generating firm might act when incentivized to invest in alternative technologies. Results indicate that – under specific circumstances – having fewer investment options available in net-zero technologies, speeds up investment. In addition, we find that policy interventions can be effective in bringing the investment decision forward. Although incentive payments are found to be somewhat effective, policies that explicitly define consequences for not meeting future emissions targets appear to be more effective at accelerating net-zero electricity investments.

Bio
De Weerdt’s research interests include the intersection between sustainability and economics, the political economy of a circular economy, and the economics of climate change. He mostly uses real options and econometric techniques in his research. He has a Ph.D. in Applied Economics from the University of Antwerp (Belgium), a masters in Economic Policy, and an additional degree in law (LLB). For his Ph.D. dissertation, he analyzed the market acceptance of circular plastics in Europe. Previously, he was also a member of the Flemish Circular Economy Policy Research Center, a group of researchers who are policy-oriented and study the circular economy.

Tubagus Aryandi (Arya) Gunawan[1]

Postdoctoral Research Associate
Principal Investigators: Eric Larson[1], Chris Greig[1]

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Towards Optimal Spatio-Temporal Design of CCS Hubs in Louisiana

Abstract
Carbon capture and storage (CCS) hubs are expected to play important roles in meeting carbon emission reduction goals in the U.S. and elsewhere. Gunawan is developing methods tools for designing cost-optimized regional CCS hubs, using heavily-industrialized Louisiana as an initial case study. Louisiana has a goal of cutting total CO_2 emissions in half by 2030 and to net-zero by 2050. His work includes (1) process simulations to size CO_2 capture equipment, (2) CO_2 pipeline simulations to

determine routes, and (3) assessments of storage potential. These elements will be combined to evaluate alternative potential time-evolutions of CCS networks.

Bio
Gunawan's research interests include techno-econo-environmental modelling of clean energy systems, electrofuel production systems, supply-chain optimization, sector coupling, energy storage, renewable energy, and energy economics. He obtained a BEng in chemical engineering from the University of Indonesia, an MSc in energy engineering from the Technical University of Berlin, and a Ph.D. in mechanical engineering from the National University of Ireland (Galway). As part of his Ph.D. dissertation, he developed an online decision support tool for deploying renewable hydrogen in Northwest Europe. He additionally was involved with the modeling of solar-based synthetic liquid fuels production at the German Aerospace Center (DLR).

Jordan Hamel[1]

1st Year Ph.D. Candidate
Principal Investigator: Claire White[1,2]

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Creating Acidic Conditions for Olivine Dissolution Using Sulfolobus acidocaldarius: Toward a Net-Negative CO_2 Bio-Based Construction Material

Abstract
Olivine $(Mg,Fe)_2SiO_4$ is a naturally abundant mineral that can be used to permanently sequester CO_2 via formation of $MgCO_3$, but olivine reactivity is comparative low and thus has required the use of manufactured strong acids or high pressures. In this research, sulfur oxidizing *Sulfolobus acidocaldarius* is used to produce sulfuric acid. Preliminary experiments have grown *S. acidocaldarius* with and without sulfur at 75 ℃ and a starting pH of 3. The cultures with sulfur maintained a lower pH than those without. Future work includes cultivating *S. acidocaldarius* at lower pH (1-2) and determining if the archaea augment olivine dissolution mechanisms.

Bio
Hamel received her bachelor's degree in materials engineering from University of California Los Angeles in 2021. Previously, her interest in sustainability led her to work at a technology company in the waste-hauling industry, which opened her eyes to the world of trash! This experience ignited her passion for sustainable materials and inspired her to join Claire White's lab, where she works on alternative cements that store CO_2.

Ganesh Hegde[1]

Postdoctoral Research Associate
Principal Investigators: Malini Nambiar[2], Cecelia Isaac[1], Chris Greig[1], Eric Larson[1], Jesse Jenkins[1,3]

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[2] Center for Policy Research on Energy and Environment
[3] Mechanical and Aerospace Engineering

Assessing Resources and Infrastructure Implications of India's Energy Transition

Abstract
India's energy transition is at a critical juncture. The recent policy announcements for the national energy transition are ambitious, but the energy transition is a complex socio-economic, cultural and political process that is also capital intensive. In this study we analyze spatio-temporal implications of current policy initiatives on resources and infrastructure for India's energy transition. We attempt to identify candidate sites for renewable energy systems expansion while understanding the implications on socio-economic linkages and resource constraints. Further, our study aims to provide a comprehensive roadmap for the country's stated ambition to transition to net-zero greenhouse gas emissions by 2070.

Bio
Hegde's research interests include energy system modeling, energy inequality, policy analysis, and understanding technology-development linkages. He is currently working on India's energy pathways for achieving net-zero carbon emissions. Hegde has a master's degree in power and energy system engineering from Bangalore University and a Ph.D. from IIT Bombay. His Ph.D. dissertation explores rural electrification policy evolution in India while analyzing electricity consumption inequalities in the country. He is an amateur chess and badminton player, an avid reader, and an outdoor enthusiast.

Shannon Hoffman[1]
4th year Ph.D. Candidate
Principal Investigator: José Avalos[1,2]

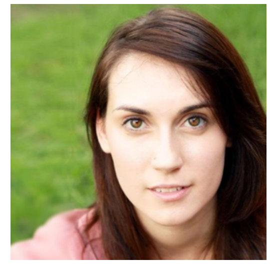
[1] Department of Chemical and Biological Engineering
[2] Andlinger Center for Energy and the Environment

Sustainable Production of Animal Proteins Using Optogenetics in the Yeast *Pichia pastoris*

Abstract
The livestock industry is a major greenhouse gas emitter worldwide. One way to reduce emissions is to produce animal proteins using microbes, like *Pichia pastoris*. Though this approach is used industrially, a pitfall is that this yeast requires methanol to induce production. To make this option sustainable, methanol-free production methods are needed. We address this challenge by creating genetic tools that induce production with light rather than methanol. This system has been used to produce animal proteins relevant to the food and biomaterial industries, and will open opportunity to reduce emissions and lower our dependence on livestock as a whole.

Bio
Hoffman earned a bachelor's degree in chemical engineering from the University of Dayton. Since coming to Princeton, she has pursued her passion of using biology to solve sustainability challenges as a Ph.D. candidate in the Avalos Lab. She envisions that the processes, tools, and strains that she is developing will open opportunities to sustainably produce better vegan foods, new biomaterials, and other products using yeast. After earning her Ph.D., she plans to continue her research in an industrial setting. Hoffman is the co-recipient of the 2022 Maeder Graduate Fellowship in Energy and the Environment.

Therese (Tess) Kichuk[1,2]



3rd year Ph.D. Candidate
Principal Investigator: José Avalos[3,4]

[1] Department of Molecular Biology
[2] Robert Wood Johnson Medical School, Rutgers University
[3] Department of Chemical and Biological Engineering
[4] Andlinger Center for Energy and the Environment

Analysis of Mitochondrial Morphology Changes for Sustainability Applications

Abstract
Yeast-derived biofuels have the potential to play an important role in our fight against climate change by helping decarbonize the transportation sector. Our lab has previously shown that mitochondrial compartmentalization increases production of valuable biofuels such as isobutanol. Preliminary evidence, however, suggests that biofuel production by mitochondrially localized biosynthetic pathways is impacted by mitochondrial morphology. In this work, we develop and apply a new method of analysis to investigate the mitochondrial morphology and inter-organelle contact of yeast in respiratory and fermentative media. This novel approach could aid in predicting high isobutanol-producing strains and determining how to further improve existing strains.

Bio
Kichuk is an M.D./Ph.D. candidate in the Avalos Group. Prior to joining the lab, she received a bachelor's degree in biochemistry from Barnard College. She is interested in mitochondrial dysfunction and the impact of climate change on human health. Her research applies metabolic engineering approaches to the study of cellular and organelle function. After completing the Ph.D. program, she plans to return to medical school.

Hongxi Luo[1]

Postdoctoral Research Associate
Principal Investigator: Eric Larson[1]

[1] Andlinger Center for Energy and the Environment

Biopower with Carbon Capture via Molten Carbonate Fuel Cells

Abstract
Biopower with CO_2 capture and storage generates negative emissions, which will be needed to meet carbon-mitigation goals. The most mature technology for CO_2 capture from combustion power plants, based on amine chemistry, carries significant efficiency penalties. The molten carbonate fuel cell (MCFC) is gaining attention as a more energy-efficient CO_2 capture option, but its techno-economic feasibility with biomass has not been previously elucidated. We present self-consistent process modeling that quantifies the efficiency benefits of MCFC over amine capture for coal power plants. In ongoing work, we are adapting our models for biomass combustion power plants.

Bio
Luo's research interests include process modeling, life cycle assessment, and techno-economic assessment of energy systems. He is currently working on the assessments of different thermochemical conversion of biomass coupled with carbon capture and storage to mitigate climate change. Hongxi received a B.S. in chemical engineering from the University of Missouri-Columbia and East China University of Science and Technology, and a Ph.D. in chemical engineering from the University of Virginia. Previously, Luo worked as a R&D manager to optimize the environmental and economic performances of

full-scale sludge pyrolysis plants and develop practical applications of sludge-derived biochar in the context of circular economy.

Debra A. Keiser[1]

2nd Year Ph.D. Student
Principal Investigator: Claire E. White[2,3]

[1] Department of Chemistry
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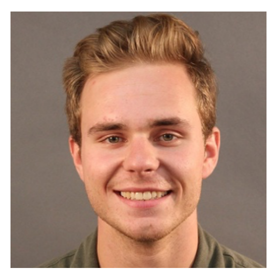
[3] Andlinger Center for Energy and the Environment

Improving the Sustainability of Concrete Through Augmenting Chemical Composition – The Role of Molecular Simulations

Abstract
Replacing ordinary Portland cement with supplementary cementitious materials (SCMs) reduces the cement industry's carbon footprint but can significantly alter the structural and compositional properties of calcium-silicate-hydrate (C-S-H) gel, the main strength-giving component of concrete. This may affect how concrete performs over its service-life. Here, molecular simulations are utilized to understand how SCMs affect the structure of C-S-H gel, with the aim of using resultant structures to assess the impact of gel chemistry on aqueous ion sorption. Fundamental insight drawn from these simulations will be used to guide the industrial sector to tailor cement compositions that achieve optimal serviceability of concrete.

Bio
Keiser is a second-year graduate student in the Chemistry Department at Princeton University. She earned her Bachelor of Science in Chemistry from Stony Brook University in 2019, where she also conducted mechanistic investigations of the chlorination of steroidal compounds in wastewater using density functional theory. After her arrival at Princeton in 2020, Keiser joined Professor Claire White's research group and currently utilizes both classical and quantum mechanical computational methods to model sustainable cementitious materials.

Eric O'Neill[1]



4th Year Ph.D. Candidate
Principal Investigator: Christos Maravelias[1,2]
with Kay Seo[3], Kenji Yoshihira[3], and Chris White[3]

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An Agent-Based Network Optimization Framework for Supply Demand Matching in Production Systems

Abstract
Production systems typically involve a number of interconnected agents that exchange materials, energy, and emissions. When operated independently, these agents may behave sub-optimally from a global perspective with respect to a centralized decision maker's objective. In this work, we aim to develop a generalized network optimization framework that can be used to identify opportunities for agent-agent cooperation. We present a multi-level model that separates the network

structure from the underlying local agent models to find centralized solutions that can improve the cost, energy, and environmental performance of interconnected production systems.

Bio

O'Neill is a fourth year Ph.D. student in the Department of Chemical and Biological Engineering with a focus in developing stochastic mixed-integer linear programming models to study cellulosic biofuel supply chains. He is interested in applying mathematical optimization techniques to large scale systems to study how efficient design and operation can achieve benefits to the economy, energy, and the environment.

Ange Nzhiou[1]

Fulbright Visiting Professor

Princeipal Investigator: Claire E. White[2,3,] Amel Ghogia[1], Lina Maria Romero Millan[1]

[1] Université de Toulouse, IMT Mines Albi, Centre RAPSODEE

[2] Civil and Environmental Engineering

[3]Andlinger Center for Energy and the Environment

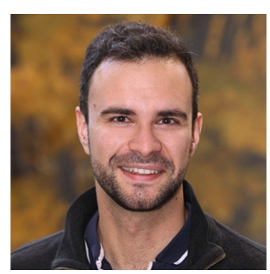
Creation of Graphitic Biocarbon from Poorly Graphitizable Waste Bioresources via Iron Catalysts

Abstract

The production of highly graphitic carbon from waste bioresources may be the basis of an environmentally friendly approach to synthesize graphene. However, cellulose, the most abundant constituent of waste bioresources, is classified as poorly graphitizable as a standalone material. Here, we show that it is possible to obtain graphitic domains in thermally-treated cellulose by the use of iron that acts as a catalyst. From Raman spectroscopy, X-ray scattering and transmission electron microscopy, we find that the graphitic domains are located on the peripheral of the iron nanoparticles, and that these domains increase in size with processing temperature.

Bio

Nzihou is a distinguished professor of Chemical Engineering at the RAPSODEE Research Center-CNRS, Institut Mines Telecom, IMT Mines Albi (France). He is currently a Fulbright visiting professor at Princeton University. His main research fields and expertise are energy and added-value materials from biomass and waste; bioresources to biochar, graphitic materials and graphene; hydrogen and syngas production from bioresources; elaboration, functionalization of carbon and phosphate-based composites / hybrid materials (sorbents, catalysts, energy carriers, sensors) for energy and depollution; thermochemical processes (pyrolysis, gasification, reforming); behavior of pollutants such as heavy metals and aerosols (fine particles).



Fernando Temprano-Coleto[1]

Distinguished Postdoctoral Fellow

Principal Investigator: Howard A. Stone[2]

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[2] Department of Mechanical and Aerospace Engineering

Combining Water Filtration and Disinfection Through Diffusiophoresis

Abstract
The phenomenon of *diffusiophoresis* ---the spontaneous migration of solid particles in a fluid in response to chemical gradients--- has attracted increasing attention in recent years, with applications ranging from fabric cleaning to particle delivery in porous materials. Here, we focus on diffusiophoresis as a method for membraneless water filtration, which has been shown to yield enormous energy savings compared to traditional filtration. We provide model results for the maximum efficiency achievable by this technique, as well as theoretical evidence that the usage of chlorine compounds can achieve the same effect with the added benefit of water disinfection.

Bio
Temprano-Coleto is a Distinguished Postdoctoral Fellow in the Andlinger Center for Energy and the Environment. His research interests lie at the intersection of fluid dynamics, physical chemistry and applied mathematics, with an emphasis on environmental applications. He is mainly concerned with the study of *diffusiophoresis* as a physical mechanism for the characterization and remediation of microplastics. He earned a bachelor's degree in mechanical Eegineering from Universidad Politecnica de Madrid, Spain, in 2015. He then completed his master's (2018) and his Ph.D. (2021) in mechanical engineering at the University of California Santa Barbara, joining Princeton University in October 2021.

Qingyu Xu[1]
Postdoctoral Research Associate
Principal Investigator: Jesse D. Jenkins[1,2]
Collaborators: Neha Patankar[1], Aneesha Manocha[2]

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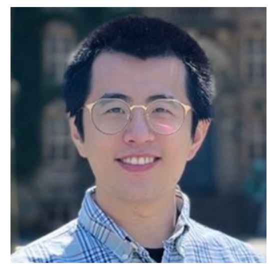

24/7 Carbon-Free Electricity Procurement: Procurement Strategy, Cost, and Emission Reduction

Abstract
Large energy buyers' voluntary clean energy procurement has been helping accelerate the deployment of clean energy around the globe. 24/7 carbon-free electricity (CFE) procurement can be the next frontier: buyers procure clean electricity to match their electricity demand, *hour-by-hour*. This study investigates the impact of some California commercial & industrial consumers participating in 24/7 CFE procurement. We find that 24/7 CFE participants can drive early deployment of advanced, "clean firm" generation like carbon capturing and sequestration and long-duration storage. Although requiring a cost premium, 24/7 CFE procurement can eliminate buyers' carbon footprint and reduce grid-wide emissions as well.

Bio
Xu focuses his research on decarbonization policies in the U.S. power sector/market. Using optimization-based power system models, he asks and addresses two questions: what policies can cost-effectively and robustly reduce carbon emissions? And how should the power sector respond to these potential policies? Xu received his Ph.D. and masters at the Department of Geography and Environmental Engineering at Johns Hopkins University. He received his bachelor's degree at Sun Yat-sen University, China.

Anita Zhang[1]
1st Year Ph.D. Candidate
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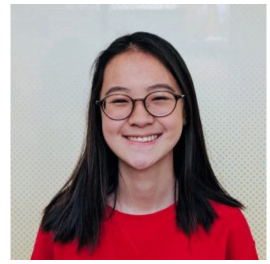

Uncovering the Durability of Sustainable Cements

Abstract
The permeability of cement paste dictates its durability and long-term performance. However, for sustainable alternative cementitious materials, such as alkali-activated metakaolin (AAMK), permeability data remain scarce. Here, we employed the novel beam-bending technique to quantify permeability of AAMK, where preliminary experiments were carried out to accurately determine the pore solution of the AAMK paste and thus the most appropriate immersion solution for the technique. *In situ* leaching tests were used to collect solutions that were subsequently characterized using a pH meter and inductively coupled plasma-atomic emission spectroscopy (ICP-AES). Preliminary beam-bending tests of AAMK using this new pore solution information have provided promising findings.

Bio
Anita Zhang received her bachelor's degree from Cornell University in December 2020, majoring in civil engineering and minoring in applied math. There, she studied earthquake nucleation. Between undergraduate and graduate school, she worked at a sustainability-minded civil engineering B-Corp, Taitem Engineering, in Ithaca, NY and performed design calculations and life cycle assessments for various projects. She also completed two internships with Arup's Advanced Technology and Research team in New York City, conducting detailed structural analyses and developing digital tools. At Princeton, she focuses on the durability of alkali-activated materials and hopes her work can lead to wider use of sustainable cements.