Rutgers Energy Institute

SEEKING SOLUTIONS TO GLOBAL ENERGY CHALLENGES

Energy Economics, Environment, and Policy Systems

Carbon Negative Technology

Bioenergy and Bioproducts

Nanomaterials for Catalysis, Solar and Energy Storage

Catalysis

RUTGERS

Energy Institute

THE RUTGERS ENERGY INSTITUTE IS TAKING A LEADING ROLE IN THE NATIONAL DRIVE FOR NEW INVESTMENTS IN ENERGY RESEARCH AND DEVELOPMENT.

Clean energy is the grand challenge of the 21st century. Access to affordable clean energy is indispensable to the economic vitality of the nation, the health of its inhabitants, and the biodiversity of the planet. Its pervasive influence on all aspects of human activity, determines the range of opportunities in which citizens can participate, from local to global. The paths forward towards decarbonizing our energy sources require participation from scientists, engineers, economists, policy researchers, businesses, as well as an informed public. The Rutgers Energy Institute (REI) brings together people with the right knowledge and skills from across disciplines to advance our progress down the clean energy path.

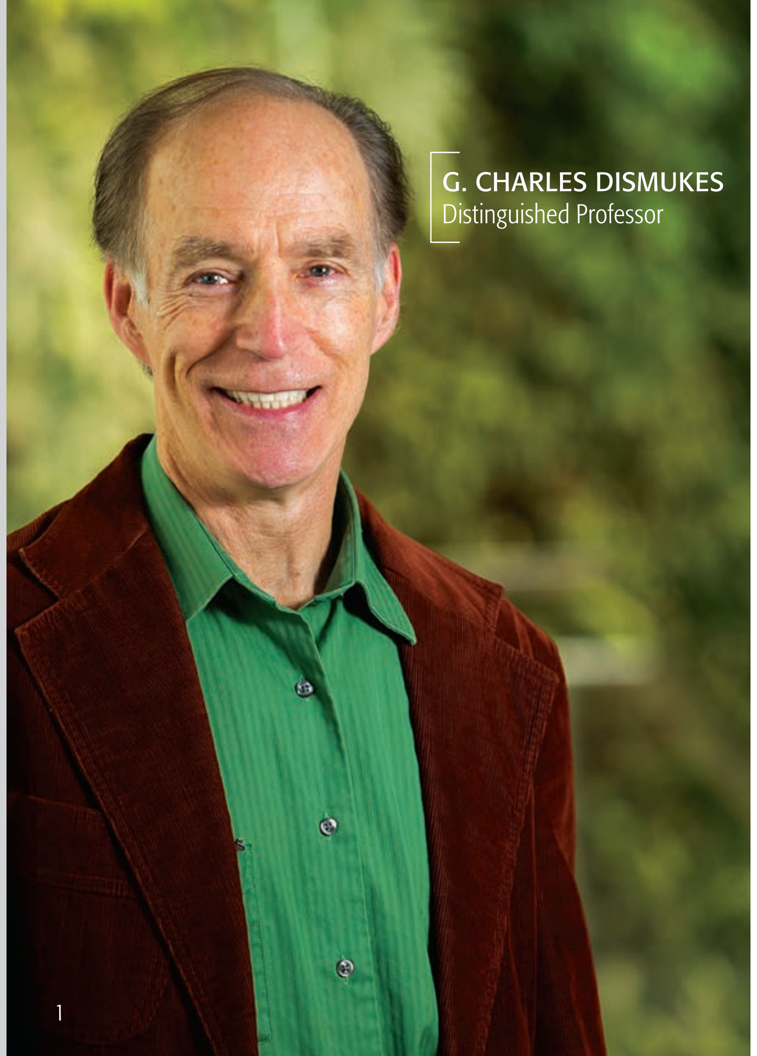
REI is a hub for research, education, policy advice, and outreach. Since its formation in 2005, the institute's mission "to foster both fundamental and applied scientific research and policy research to develop sustainable energy production compatible with economic growth and environmental vitality" has not changed.

Clean Energy is the Grand Challenge of the 21st Century

The REI has five core, interlinked themes, spanning across school boundaries. These themes do not represent the breadth of the expertise of REI faculty; rather, they are areas of crosscutting strengths and opportunities that are fertile ground for collaborations and are critical to decarbonizing energy supplies in the coming decades. The five themes represent current strengths and are topics in which REI has invested and will continue to invest resources.

These themes are:

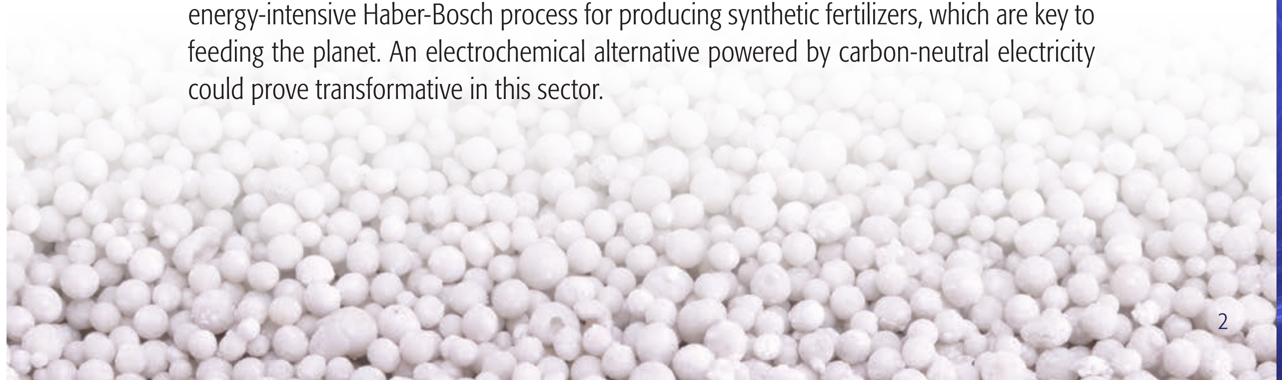
- Catalysis
- Nanomaterials, Photovoltaics, and Storage
- Bioenergy and Bioproducts
- Carbon-Negative Technologies
- Energy Economics, Environment, and Policy Systems



G. CHARLES DISMUKES
Distinguished Professor

"Charles Dismukes and his group investigate the science of catalysis particularly photo- and electro-catalysis, using an integrated theoretical-experimental approach that incorporates knowledge from biology, chemistry and physics to understand the fundamental principles and translate that knowledge into proof of principle devices and solutions. We study systems extending from natural photosynthetic organisms and isolated enzymes to artificial photosynthetic constructs and solar fuel cells. Topics in catalysis that we study include water splitting, carbon dioxide capture and reduction to chemicals, carbon metabolism in phototrophs, dinitrogen capture and reduction."

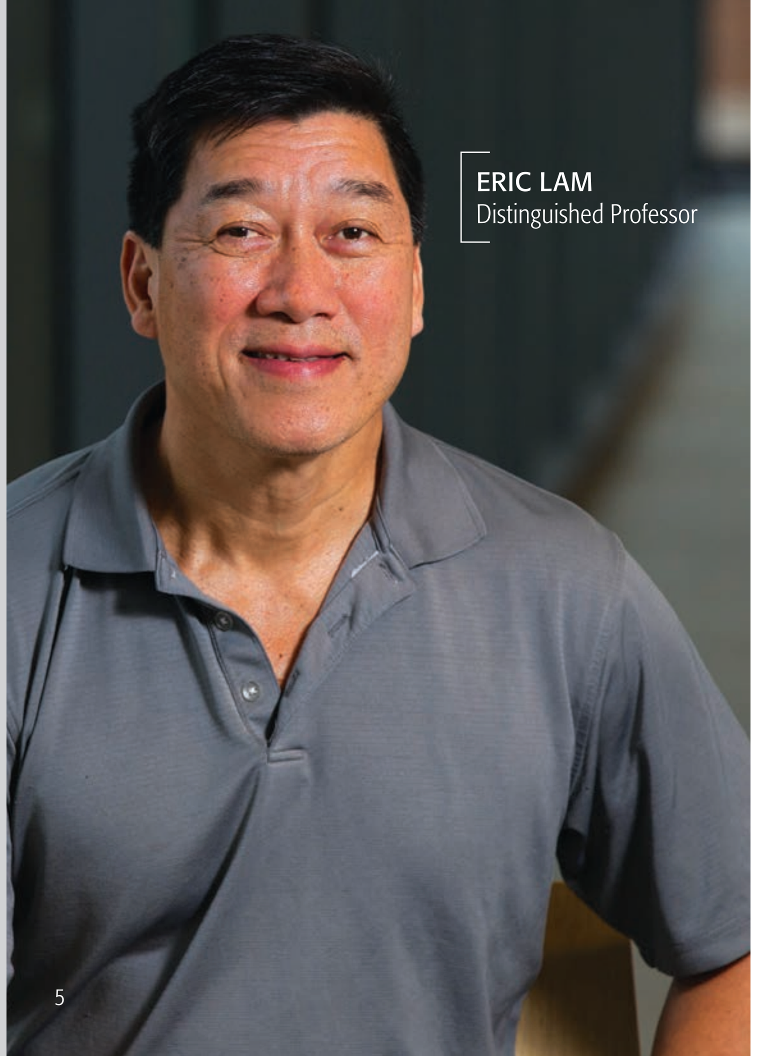
Catalysis is an essential technology for fuel cells and other energy conversion systems, combustion devices, pollution control systems, agriculture, chemical, materials manufacturing, and virtually every product that impacts our lives. Future catalysis research must replace pioneering, legacy technologies with energy efficient processes that use less of scarcer raw materials and recalcitrant feedstocks. The REI is developing a major center for catalysis at Rutgers, of which a core theme will be related to energy production/storage and developing alternative catalysts for energy intensive processes important to agriculture. REI faculty are on the cutting edge of catalysis research with strong faculty at all ranks in multiple departments and schools. The faculty are working on several fronts to produce clean energy from renewable energy sources, such as hydrogen for fuel cells-produced by electrolysis of water, transportation fuels from non-edible biomass, and solar fuels produced from carbon dioxide and water using solar electricity. REI scientists and engineers are pioneering the development of electro-catalysts and solar cells needed to create solar fuels. REI researchers are also working on electrochemical alternatives to the energy-intensive Haber-Bosch process for producing synthetic fertilizers, which are key to feeding the planet. An electrochemical alternative powered by carbon-neutral electricity could prove transformative in this sector.



LAURA FABRIS
Associate Professor

"My group performs multidisciplinary research at the interface between chemistry, materials science, physics, and biology. We study both theoretically and experimentally how plasmonic nanomaterials can be rationally designed to address fundamental challenges in molecular imaging, catalysis, or sensing. From the energy standpoint, we synthesize hybrid nanomaterials that optimize generation and transfer of hot electrons leveraging light absorption in the visible and near infrared, so that photoreduction reactions, such as hydrogen generation from water, can be carried out more efficiently and at low temperature by maximizing the absorption of solar radiation."

New nanomaterials may be crucial in at least two core carbon-neutral energy solutions: solar photovoltaics and energy storage. They are also key to the development of innovative catalysts. The REI has several key research groups working on nanomaterials for clean energy, and for five years hosted an IGERT focused on this topic. Nanomaterials synthesis is one of REI's strengths. It is conducted by numerous faculty members who are interested in leveraging the properties of a wide range of nanostructures to address long-standing issues in energy-relevant research areas, such as plasmonic metal nanostructures for photovoltaics and catalysis, or two-dimensional materials for catalysis, solar, and energy storage applications. Rutgers' Energy Storage Research Group is a world-leading enterprise at the forefront of energy storage research.

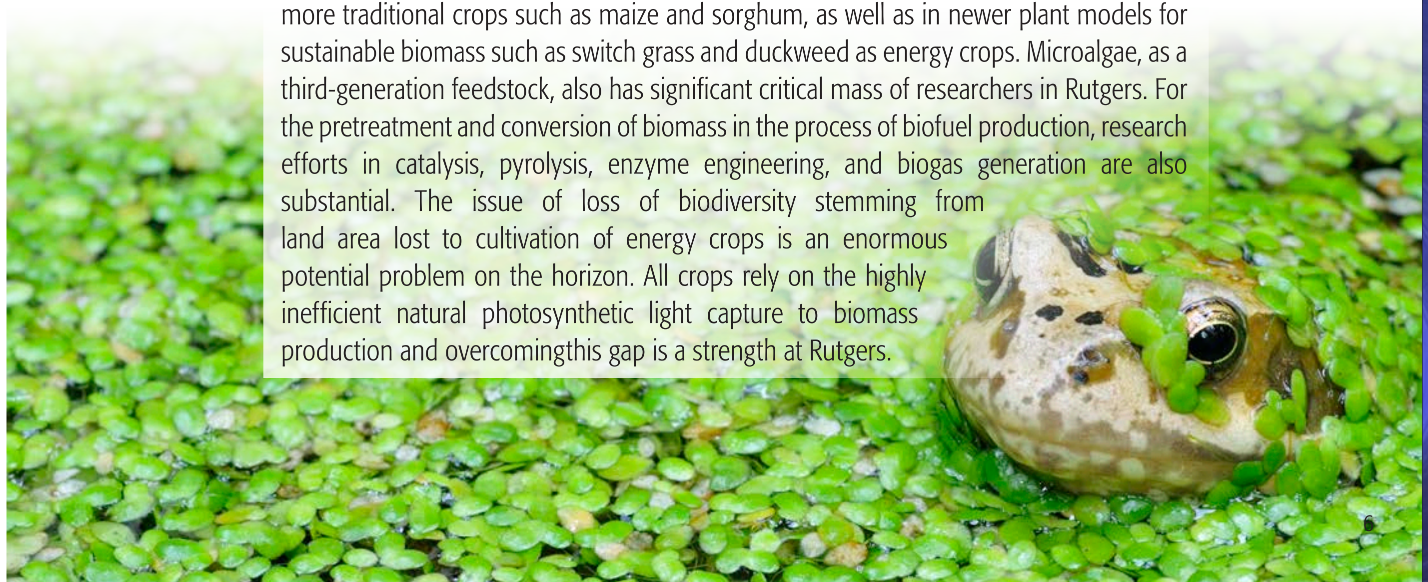


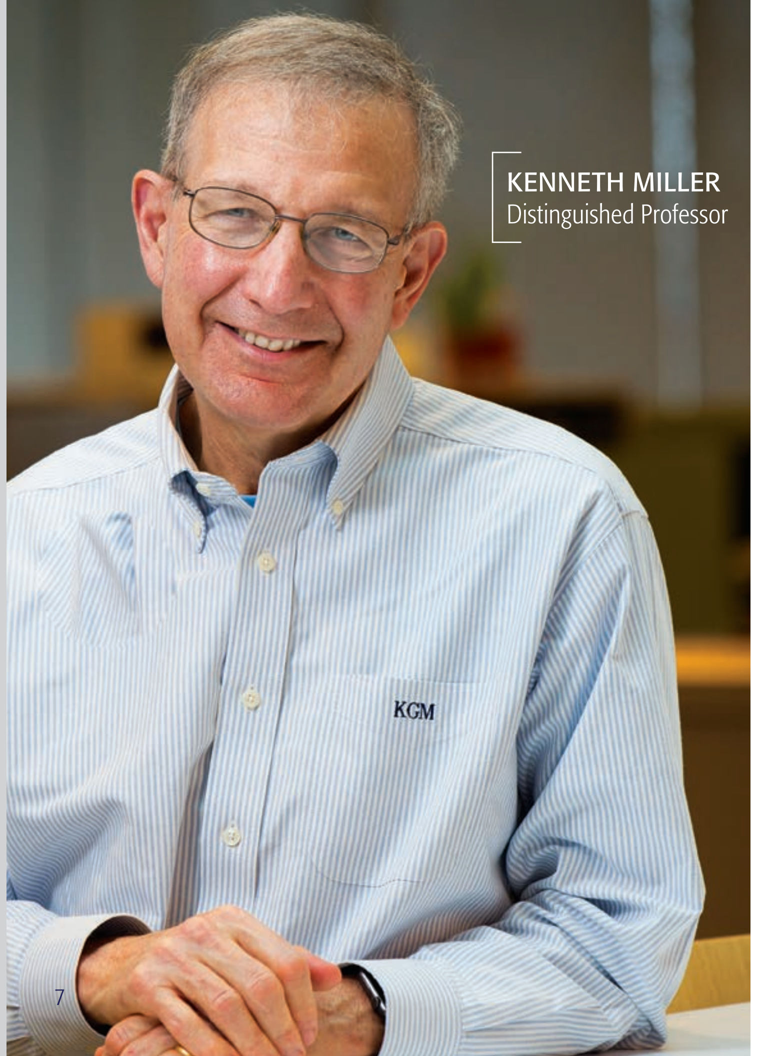
ERIC LAM
Distinguished Professor

"The twin challenges of Climate Change and projected population growth will require rethinking of the way we produce and distribute our food and feedstocks while minimizing the damages to the fragile ecosystem of this planet. In my lab over the past 9 years at the School of Environmental and Biological Sciences of Rutgers, we have worked toward realizing the potential of a tiny aquatic plant, duckweed, as a platform for new agriculture that can help change the paradigm of feedstock production. Working with economists, the Aquaculture Innovation Center, and Engineers, we are constructing modular, scalable duckweed production machines that can be deployed in both rural and urban settings as well to integrate with wastewater generating systems to reclaim precious nutrients as well as to minimize feed costs. With the largest living collection of duckweed strains in the world, the Rutgers Duckweed Stock Cooperative holds the germplasm for natural variations in this remarkable plant family that can be tapped for solutions to address our society's pressing needs. In sum, we hope that our work will work toward making this planet a better place by creating technologies that will address fundamental issues of food security and environmentally sustainable production of bioproducts."

REI's bioenergy research complements its work on solar fuels, exploring alternative pathways to generating drop-in, low-carbon replacements for existing liquid fuels. It also complements REI's work on carbon capture and storage (CCS): bioenergy coupled to CCS is a major potential pathway for accelerating the removal of carbon dioxide from the atmosphere.

REI's current strength in bioenergy and bioproducts is primarily in fundamental photosynthesis, feedstock development, and in technologies relating to biomass pretreatment or conversion. Significant strength can be found in plant breeding and genomics for more traditional crops such as maize and sorghum, as well as in newer plant models for sustainable biomass such as switch grass and duckweed as energy crops. Microalgae, as a third-generation feedstock, also has significant critical mass of researchers in Rutgers. For the pretreatment and conversion of biomass in the process of biofuel production, research efforts in catalysis, pyrolysis, enzyme engineering, and biogas generation are also substantial. The issue of loss of biodiversity stemming from land area lost to cultivation of energy crops is an enormous potential problem on the horizon. All crops rely on the highly inefficient natural photosynthetic light capture to biomass production and overcomingthis gap is a strength at Rutgers.





KENNETH MILLER
Distinguished Professor

"Our lab at Rutgers is focused on understanding the past 200 million years of Earth history and how the accumulation of sediments from this period informs us of sea-level history. We collect and archive core samples and seismic profiles (sonograms of the Earth) that record sea-level changes. Deciphering sea level provides a prediction of sands reservoirs and mud/shale confining units (seals), allowing evaluation of water (aquifer) and carbon storage resources. Our recent studies have evaluated onshore and offshore Mid-Atlantic reservoirs that are ideally suited for storage of large volumes of carbon dioxide collected from point sources such as power plants, and provide one of the few means of attaining negative carbon emissions."

Achieving international climate goals will not only require preventing CO_2 emissions by decarbonizing the energy system – they will also require accelerating the removal of CO_2 from stack gases and the atmosphere through carbon-negative technologies. REI scientists are researching two carbon negative technologies currently: Bioenergy coupled to Carbon Capture and Storage (BECCS) and Carbon Capture and Storage (CCS) in geological reservoirs. Geological storage of captured CO_2 is an important piece of the mitigation puzzle. REI geologists are leading projects to test future areas for carbon storage off the coast of the eastern US, exploiting reservoirs originally thought to contain oil and gas (but shown by prior drilling to be dry) but are now known as excellent for storage. REI economists are assessing the costs and benefits of BECCS deployment in the northeastern U.S. With this work tied to other research threads on bioenergy and solar fuels, REI has the potential to be a global leader in this technology. Meanwhile, REI engineers have successfully invented and commercialized a CO_2 avoidance and utilization technology that has the potential to reduce CO_2 emissions of the cement and concrete industry – currently responsible for about 5% of global CO_2 emissions – by up to 70%. In addition, Rutgers engineers are investigating materials that utilize CO_2 for use for automotive parts, investment casting, lightweight packaging, agriculture, fasteners, armor and many other applications. A key to enabling this approach is the ready availability of CO_2. Scientists affiliated with Rutgers continue to develop state-of-the-art carbon capture systems that could be paired to enable extensive mineralization.

KEVIN LYONS
Associate Professor

"My research on developing and integrating global environmental, social, economic, ethical criteria and data into supply chain/procurement systems and processes has afforded numerous industries the ability to increase their bottom line and impress their board members all while doing the right thing by the environment, their clients, and their local and global community."

Aside from researching environmental and economic impacts of products' life cycles along the supply chain, I have also created the supply chain archeology and supply chain waste archeology research disciplines and have researched and written extensively on conducting environmental health-checks on global supply chains and the resulting benefits of reduced risk management impacts and costs. "

RACHAEL SHWOM
Associate Professor

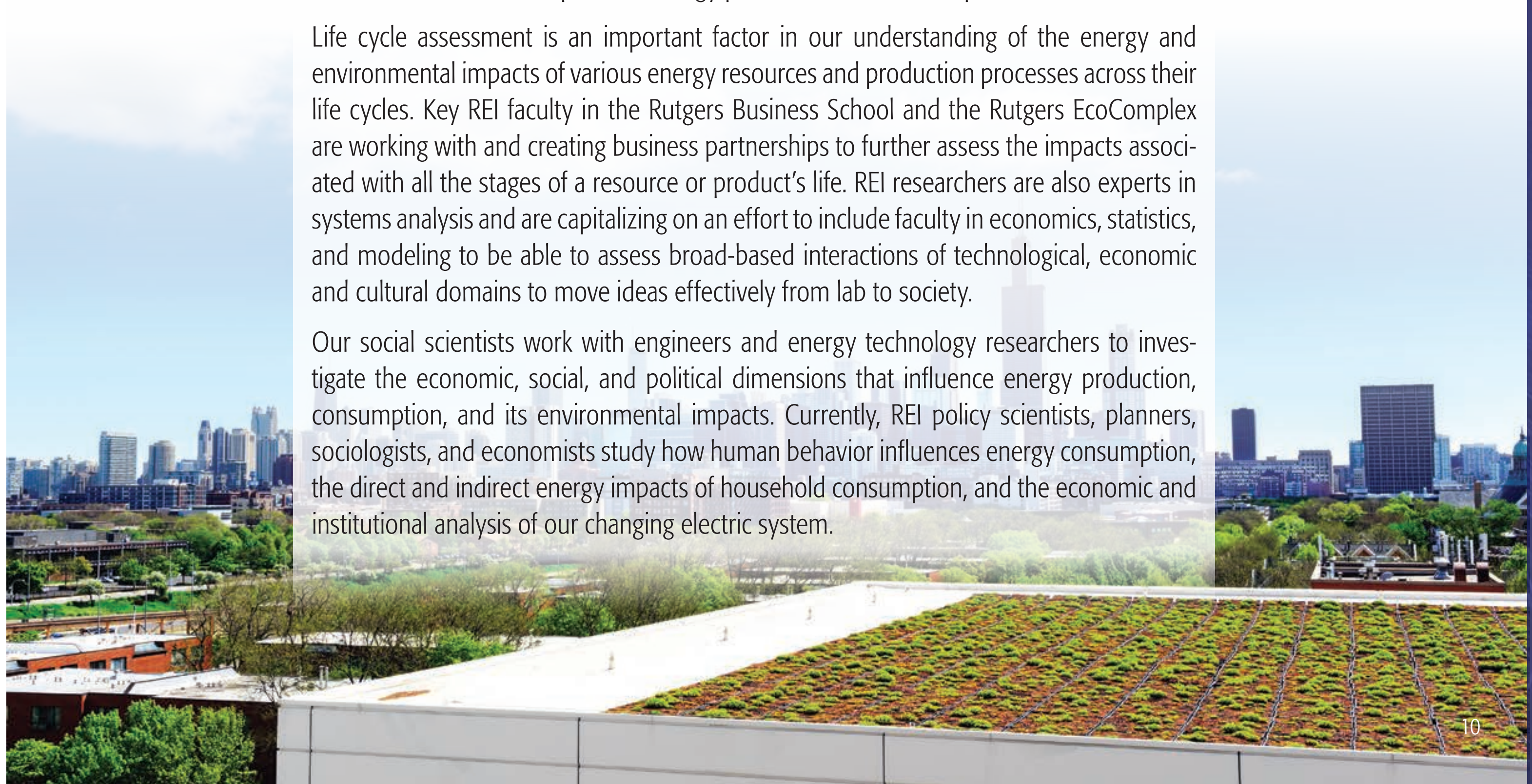
"Our energy system is more polluting and wasteful than it needs to be given state of the art technology. My research focuses on how we can change this. I empirically test what messages are most effective in helping households to reduce their energy use. I use role playing games, surveys, and working with people in their homes to provide feedback about the impacts of their food, energy, and water consumption. We hope by getting the right messages to the right people we can change behaviors to save resources and reduce household environmental impacts."

Energy Economics, Environment, and Policy Systems

The clean energy challenge is not just about technology - it's a societal challenge and cannot be solved without understanding the socio-economic systems in which it takes place. Our team of experts provides insight into the environmental, economic, political and social factors that impact our energy production and consumption choices.

Life cycle assessment is an important factor in our understanding of the energy and environmental impacts of various energy resources and production processes across their life cycles. Key REI faculty in the Rutgers Business School and the Rutgers EcoComplex are working with and creating business partnerships to further assess the impacts associated with all the stages of a resource or product's life. REI researchers are also experts in systems analysis and are capitalizing on an effort to include faculty in economics, statistics, and modeling to be able to assess broad-based interactions of technological, economic and cultural domains to move ideas effectively from lab to society.

Our social scientists work with engineers and energy technology researchers to investigate the economic, social, and political dimensions that influence energy production, consumption, and its environmental impacts. Currently, REI policy scientists, planners, sociologists, and economists study how human behavior influences energy consumption, the direct and indirect energy impacts of household consumption, and the economic and institutional analysis of our changing electric system.



Professor Laura Fabris working with grad students Supriya Atta, Kholud Dardir, and Sakhi Sardar to monitor the emission of gold nanoparticles employing a fluorescence microscope.

Over the past decade, the REI has provided a forum for discussion of issues and seed money for faculty, students and professional staff to collaboratively work together to foster new research and educational experiences. The result has been a phenomenal growth of the University's research portfolio on energy writ large. However, the value of the REI is not simply monetary – it has developed an interactive forum across the schools that has enabled new collaborations to blossom, and both new energy policy frameworks and technological advances to be achieved. The REI has been instrumental in developing new courses and providing information about energy-related curricula for undergraduate and graduate students. Through seminars, symposia and virtual media, the REI also helps the broader community to understand the complexities of transforming our nation's energy generation in coming decades.

Professor Robert Hayes with Krystal House, Sara Youssef and Jonathan Roth study the nanoscale structure, dynamics and forces of novel liquid electrolytes.

Dr. Joseph Brodie discusses the development of offshore wind energy with student interns Christine Leary, Jaden Dicopoulus, and Daniel Prakash.

STUDENTS THAT MAKE A DIFFERENCE

Education

The REI plays an important role in the education of students and the public about energy. It has been instrumental in developing a graduate certificate in energy (the first in NJ), new courses and providing information about energy-related curricula for undergraduate and graduate students. Graduate students have received funding for interdisciplinary research projects co-advised by faculty from multiple departments. The REI provides support for undergraduate interns to conduct energy-related research during the summer and academic year. REI-sponsored interns have worked in numerous research labs, at the Rutgers EcoComplex, and with Rutgers facilities. They have been accepted in the finest graduate programs in the nation.

Course Development

REI develops new curricula that bridge disciplines across the schools, prepares students for multifaceted approaches to alternative energy questions, and reframes thinking to develop renewable, alternative energy sources. The REI launched a multi-instructor, multidisciplinary undergraduate core course on energy and has spurred the development of a number of other collaboratively taught courses.

REI Summer Internships

The REI offers summer internships to a select group of motivated undergraduate students. They are intended to help students understand the breadth of the energy challenge, from the environmental impacts that motivate the transition, to the technological innovation needed to create a viable new system and the socio-economic, policy, and energy system frameworks necessary to enable widespread deployment.

Professor Tsilomelekis and Hedun Wang (PhD candidate) working on assembling the optical reactor suitable for advanced spectroscopic measurements under real reaction conditions.

Graduate Certificate in Energy

First in NJ, the Graduate Certificate in Energy builds on the diversity, magnitude, and variety of Rutgers resources in science, engineering, and public policy by enabling graduate students to cross over to courses outside their graduate program and enrich their background in energy. Students receiving this certificate will have received a broad exposure to the topics and challenges in energy and they will have stronger qualifications to pursue a career in industry, government and academia upon graduation, as well as become leaders in innovation.

Research Fellowships

Each year the REI offers support for graduate students and postdoctoral associates in the broad area of energy research related to research topics relevant to the REI's mission: in basic and applied science, engineering, economics, and policy. Rutgers recently hosted two National Science Foundation-funded Integrative Graduate Education and Research Traineeships (IGERTs) in the energy arena–one in Nanotechnology for Clean Energy and the other in Renewable and Sustainable Fuels.

REI Student Support

The REI provides financial support to undergraduates and graduates annually by offering Travel Awards to facilitate student research projects, attendance at conferences, career and training activities, and networking opportunities. The awards were developed with the goal of enhancing the scholarship and success of our students and to provide richer and broader exposure to the topics and challenges in energy.

OUTREACH

REI Undergraduate Energy Contest

The REI has ran an energy contest each spring where undergraduate students submit fully analyzed solutions to green the Rutgers energy system and compete for prize money. Ian Stewart, 2016 second place winner, said "I have seen many innovative and technically feasible ideas proposed for the contest, including geothermal energy, rooftop gardens, and piezoelectric technology. One such proposal, tray-less dining halls, was actually implemented in the New Brunswick campuses during my time at Rutgers. In many ways, the research and resourceful thinking necessary for creating a proposal provides an invaluable educational experience into the deployment of renewable technologies and the proper planning and budgeting inherent in green initiatives. This type of innovative thinking and strategizing is invaluable in finding ways to cut CO_2 and other greenhouse gas emissions in an ever-warming world."

Policy Advice

The REI plays a critical role providing information to the public and to local, state governments and our federal representatives about sustainable growth and energy production. REI faculty have met with federal and state officials and served on external government panels. Our policy seminars frequently attract state officials, and our annual symposia have included former Energy secretaries and undersecretaries.

Women in Energy Initiative

The goal of the WIE program is to empower female students to take on leadership roles in the energy sector and realize their full potential. REI has collaborated with Columbia University's Center on Global Energy Policy to build a thriving community of professional women.

Public Events and Energy Policy Series

REI provides a full calendar of multidisciplinary events to engage our community and nation in pursuit of low-carbon energy solutions. Several times every term, the REI Energy Policy Seminar Series brings leading experts from various energy fields to foster dialog on state, national, and global energy policy.

Symposium

The REI flagship annual symposium takes place each spring featuring keynote addresses and panel discussions to foster open dialogue to share ideas and formulate solutions around key energy challenges. The Annual Rutgers Energy Institute symposia have brought to campus a range of notable speakers, among them former Secretary of Energy Steve Chu, former Congressman Rush Holt, and UN Intergovernmental Panel on Climate Change chair Hoesung Lee.

Assistant Research Professor and Ananya Agarwal are screening for algae strains with modified metabolism to identify candidates for biofuel production in the Falkowski group.

Research Centers & Programs

Researchers, groups, and centers throughout Rutgers University.

- Center for Advanced Energy Systems
- Center for Advanced Infrastructure and Transportation
- Center for Advanced Solid State Ionics and Energy Storage Research
- Center for Computational and Integrative Biology
- Center for Energy, Economic & Environmental Policy
- Institute for Advanced Materials, Devices, and Nanotechonology
- Institute of Earth, Oceans, and Atmospheric Sciences
- Laboratory for Energy Smart Systems
- Laboratory for Surface Modification
- New Jersey Agricultural Experiment Station
- New Jersey Climate Adaptation Alliance
- NJAES Sustainable Energy Working Group
- Rutgers Catalysis Research Center
- Rutgers Center for Green Building
- Rutgers Climate Institute
- Rutgers Discovery Informatics Institute (RDI2)
- Rutgers EcoComplex
- Rutgers Marine and Coastal Sciences
- Rutgers University Center of Ocean Observing Leadership
- Waksman Institute of Microbiology

The REI represents an interdisciplinary institute which promotes collaboration around clean energy challenges. It includes faculty, students, and centers from five schools at Rutgers, the State University of New Jersey: the School of Arts and Sciences, the School of Environmental and Biological Sciences, the School of Engineering, the Rutgers Business School, and the Edward J. Bloustein School of Planning and Public Policy. The institute draws on strategic teams of experts from academic units and research centers to work on developing renewable, sustainable alternative energy sources.

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