



**2023 ANNUAL REPORT**

**INSTITUTE FOR RESILIENT  
ENVIRONMENTAL AND ENERGY  
SYSTEMS**



*The* UNIVERSITY *of* OKLAHOMA

The Institute for Resilient Environmental and Energy Systems (IREES) works to support the development of inclusive, equitable, and sustainable solutions to critical challenges at the intersection of society, the environment, and energy systems through convergent research, interdisciplinary education, and transformative partnerships.

**IREES**

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## Land Acknowledgement

Long before the University of Oklahoma was established, the land on which the University now resides was the traditional home of the "Hasinai" Caddo Nation and "Kirikir?i:s" Wichita & Affiliated Tribes.

We acknowledge this territory once also served as a hunting ground, trade exchange point, and migration route for the Apache, Comanche, Kiowa, and Osage nations.

The University of Oklahoma recognizes the historical connection our university has with its Indigenous community. We acknowledge, honor, and respect the diverse Indigenous peoples connected to this land. We fully recognize, support, and advocate for the sovereign rights of all of Oklahoma's 39 tribal nations. This acknowledgment is aligned with our university's core value of creating a diverse and inclusive community. It is an institutional responsibility to recognize and acknowledge the people, culture, and history that make up our entire OU community."

# Note From Director Tim Filley



August 2023 marked an important milestone — it represented two years’ effort standing up the Institute for Resilient Environmental and Energy Systems (IREES) — a university-wide, multi-campus, transdisciplinary center of excellence focused on real-world challenges in support of the environment, energy, and sustainability research vertical outlined in the University of Oklahoma’s **“Lead On, University” Strategic Plan**. It also represented a personal milestone for me as it concluded my first two years as the inaugural director of IREES, two years as a member of the OU faculty in the Department of Geography and Environmental Sustainability and School of Geosciences, and my second year since moving from Indiana to become a citizen of the great state of Oklahoma.

The creation of IREES comes at a time of immense challenges and opportunities. Climate change, the reverberations of the COVID-19 global pandemic, environmental degradation, and the challenge of accelerating and ensuring just transitions to clean energy are coupled with opportunities that include new, unprecedented levels of federal research funding. The scale of the challenges and opportunities before us encourage a reimagining of how we teach, engage in research, and apply what we discover to deliver solutions that will **Change Lives**. IREES has much to build from, with Oklahoma’s longstanding leadership in energy production and abundant natural resources, a state rich in cultural diversity, the unparalleled potential for research partnerships that bring the perspectives, knowledge, and values afforded by 39 sovereign Native Nations, and strong university support with the clarity of purpose defined in OU’s new strategic plan.

As I began my tenure as the director of IREES, I was fortunate to inherit a framework outlining foundational elements for IREES, and am grateful to the multidisciplinary team, led by professors Petra Klein and Jeff Kelly, that put it together. With this blueprint in hand, I embarked on what I consider to be the two most important activities when launching any transdisciplinary endeavor — creating a space for open dialogue and listening. By the end of IREES’ first year, we refined the central research questions related to the sustainability of people and planet that IREES will aim to tackle; established our approach to supporting convergent research; built a strong leadership team to help guide our research goals, and created new partnerships and the networks we need to make real impact here in Oklahoma, across the region, and globally. Further, we hired exceptional staff to facilitate the functions of IREES and support OU faculty and our partners. We worked to identify and fill the needs for critical research infrastructure on campus. But this is just the beginning and there is much left to do.

At the center of all our efforts is a commitment to the interdisciplinary research, convergent approaches, and creative activity that is represented in the pages of this report. Also highlighted in the report are the ways we are innovating for excellence in training and education, and a look at the new partnerships we are developing. I am thrilled with our progress and inspired every day by the people, work, and potential of our institute. It is my honor and privilege as director of IREES to help our faculty, staff and students imagine how their expertise can transcend disciplinary boundaries, integrate with knowledge from non-academic partners, and engage with stakeholders of all kinds to generate resilient, sustainable solutions to the complex, intractable challenges we face.

Tim Filley, PhD  
Professor and Director  
[filley@ou.edu](mailto:filley@ou.edu)

# Building an Institute

2019-2020

The OU Board of Regents charges President Joseph Harroz, Jr. and university leadership with developing a comprehensive strategic plan for OU's future.

Tomás Díaz de la Rubia is appointed OU's new Vice President for Research and Partnerships.

The President's Academic Planning and Budget Advisory Committee gathers input from faculty, students, staff, and administration, and drafts the Strategic Plan. The Plan articulates the university's **Purpose**, the **Pillars** that outline our aspirations, the **Strategies** to carry out the Pillars, the **Tactics** required to fulfill the Strategies, and a framework to **Assess and Review** our progress.

**Pillar 5's** Strategy 2 includes creation of university-wide, multi-campus, multidisciplinary **centers of excellence in research and creative activity** focused on real-world challenges, including a focus in environment, energy, and sustainability.

The OU Board of Regents adopts "Lead On, University" — the University's first strategic plan in over a generation. Our purpose: **We Change Lives**.

2020-2021

A team of faculty, working with strategy consulting firm Thinkenomics, draft a framework outlining the foundation for launching an Institute for Resilient Environmental and Energy Systems (IREES).

Tim Filley is recruited to serve as the IREES Inaugural Director.

2021-2022

Filley joined the OU faculty and began his appointment as IREES director in August 2021. He spends the year focusing on: listening sessions, establishing partnerships, identifying federal funding opportunities, recruiting institute leadership, hiring staff, identifying infrastructure gaps and needs, establishing the Latin America Sustainability Initiative, and refining the Institute's vision and approach.

2022-2023

Standing up IREES. The progress made from July 2022 through June 2023 is reflected in this report.

# IREES Approach

Extreme weather and climate change are among the most pervasive risks to people and planet. The negative impacts to our communities, our health, and the natural environment are becoming ever more apparent, as are the impacts to the U.S. economy and economies around the world. Modern society also continues to grapple with persistent environmental challenges that are tightly connected to the infrastructure we've built and manage to meet societal needs.

Governments, investors, businesses, and civil society are taking steps to build more resilient, sustainable communities and economies. Given the scale of the technological, economic, and societal changes needed to enable these transformations, the opportunities are immense.

IREES was established to apply the full breadth and depth of OU's knowledge, resources, and expertise — combined with those from partner organizations — to address complex, interconnected, and often competing environmental and energy challenges.

## OUR APPROACH

We believe a convergence of perspectives, knowledge, and expertise from OU's community of faculty researchers and our partner stakeholders, coupled with institutional support will strengthen Oklahoma's capacity to address these pressing challenges. Our approach is based on three foundational activities:

### Enabling a culture of convergence research

- Appoint Faculty Fellows and Scholars In-Residence
- Build collaborative relationships
- Provide leadership mentoring and training
- Build critical research infrastructure
- Create a space for open dialog

### Partner and Stakeholder Development

- Establish advisory and co-creation boards
- Develop research translation and demonstration projects
- Broaden research with education and outreach activities
- Emphasize service to Oklahoma's communities

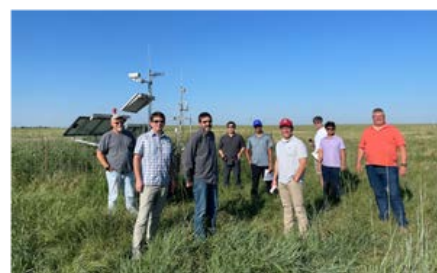
### Project Development

- Offer intellectual contributions
- Co-create research with partners
- Conduct strategic intelligence and capacity analyses
- Promote OU national/international leadership
- Establish collaboration track record

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**Building resilience is about managing change.  
But context matters.  
Resilience of what?  
For whom?  
We work to build the capacity to anticipate, prepare for, and respond to change to help enable a more sustainable and prosperous future for all.**

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# The Year in Review

## BY THE NUMBERS

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**16** RESEARCH TEAMS INITIATED

**40** AFFILIATED PROPOSALS SUBMITTED

**19** EXTERNALLY FUNDED PROJECTS

**28**

STUDENTS  
SUPPORTED

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**\$143k**

INVESTED IN  
CRITICAL RESEARCH  
INFRASTRUCTURE

---

**\$167.6M**

AFFILIATED PROPOSAL  
SUBMISSIONS

**\$27.8M**

EXTERNALLY FUNDED  
GRANT AWARDS

**6**

NEW MOUs SIGNED

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**9**

FACULTY  
FELLOWS

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**1st**

OU'S FIRST FEDERALLY  
FUNDED STEM  
RESEARCH GRANT  
WITH THE NATIVE  
NATIONS CENTER

**1000+**

PARTICIPANTS IN  
IREES EVENTS &  
WORKSHOPS

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**18**

WORKSHOPS &  
SPECIAL EVENTS  
HOSTED

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# An Accelerated Funding Landscape

New federal investments in energy research have been created via the Infrastructure Investment and Jobs Act, also known as the Bipartisan Infrastructure Law (BIL). Signed in late 2021, it will invest \$76B in new funding to accelerate the clean-energy transition and improve electric power infrastructure. Following the BIL, the CHIPS and Science Act was signed into law in August 2022, directing \$280 billion in spending over the next ten years with the majority — \$200B — for science R&D and commercialization, including clean energy R&D and STEM workforce development. Adding to these historic investments, the Inflation Reduction Act of 2022 directs new federal spending to jump-start R&D and commercialization of decarbonization technologies.

In a visit to Oklahoma in April 2023, U.S. Secretary of Energy Jennifer M. Granholm and Second Gentleman of the United States Douglas Emhoff, met with Tribal leaders and OU energy experts for a roundtable on renewable energy co-organized by IREES. The conversation focused on the potential benefits of geothermal energy to Indigenous communities in Oklahoma (see, for example, page 12). Secretary Granholm emphasized the IRA provides more than \$720 million for programs dedicated to Tribal lands and Native communities. These programs will help ensure that more Tribal households have access to affordable and clean electricity; make Native communities more resilient to the growing threats posed by climate change, including drought; and support Tribal efforts to transition to cleaner sources of energy.

**“Our discussion today honors our shared commitment to working together to develop sustainable energy solutions for people and communities across America. At OU, we are leveraging more than a century of energy expertise to unlock new energy pathways that will power future generations.”**

**—OU President Joseph Harroz Jr.**

Joining the conversation were Reggie Wassana, Governor, Cheyenne and Arapaho Tribes; Bill Anoatubby, Governor, Chickasaw Nation; John “Rocky” Barrett, Tribal Chairman, Citizen Potawatomi Nation; Jim Collard, Director of Planning and Economic Development, Citizen Potawatomi Nation; Micah White, CEO, Muscogee (Creek) Nation Tribal Utility Authority; James Williams, Director, Office of Environmental Services, Muscogee (Creek) Nation; Matthew Dannenberg, Tribal Liaison, U.S. Department of Energy; PaaWee Rivera, Senior Advisor and Tribal Affairs Director, the White House.

Participants from OU included President Joseph Harroz, Jr.; Tana Fitzpatrick, Associate Vice President of Tribal Relations and Director, Native Nations Center; Tim Filley, IREES Director, and Professor in the College of Atmospheric and Geographic Sciences and Mewbourne College of Earth and Energy; Saaed Salehi, Associate Professor, Mewbourne College of Earth and Energy; and Li Song, Lloyd G. and Joyce Austin Presidential Professor, Gallogly College of Engineering.





# Funding Landscape, *continued*

## Energy in Focus

In our first two years, IREES programming has emphasized energy-related efforts to capture the opportunities of this historic federal funding landscape, much of which is centered on the next-generation clean energy technologies needed to address the climate crisis. These opportunities were created within multiple funding agencies, including the U.S. Department of Transportation, the National Science Foundation (NSF), the Environmental Protection Agency, and the Department of Energy (DOE).

The DOE's Earthshots Initiative is just one example of the innovative new approaches funding agencies are using to catalyze decarbonization across some of the hardest to abate sectors of the economy. The 'Earthshots' are meant to tackle the toughest scientific and technical barriers to deploying the technologies we need to rapidly reduce greenhouse gas emissions.

OU is taking an all-hands-on-deck approach, integrating our diverse expertise with the knowledge and talent of partners from industry and national laboratories, as well as from the communities who will benefit from these scientific and technological breakthroughs. This report highlights examples of OU's collective efforts to meet the goals of reducing carbon emissions by 50% by the end of the decade, securing a 100% clean electrical grid by 2035, and reaching a net-zero carbon economy by 2050.



### Carbon Negative Shot™

Innovations that remove CO2 from the atmosphere and durably store it at meaningful scales for less than \$100/net metric ton of CO2-equivalent within a decade.



### Clean Fuels & Products Shot™

Decarbonizing the fuel and chemical industry through alternative sources of carbon to advance cost-effective technologies with a minimum of 85% lower emissions by 2035.



### Hydrogen Shot™

Reduce the cost by 80%, to \$1 per 1kg of clean hydrogen within one decade.



### Industrial Heat Shot™

Develop cost-competitive industrial heat decarbonization technologies with at least 85% lower greenhouse gas emissions by 2035.



### Enhanced Geothermal Shot™

Dramatically reduce the cost of enhanced geothermal systems by 90%, to \$45 per megawatt hour by 2035.



### Floating Offshore Wind Shot™

Drive down costs to \$45 per MWH by 2035 to spur U.S. leadership in floating offshore wind technology, decarbonize, and deliver benefits for coastal communities.



### Long Duration Storage Shot™

Affordable grid storage for clean power - anytime, anywhere - by reducing cost of grid-scale energy storage by 90% for systems that deliver 10+ hours of duration within a decade.



### Affordable Home Energy Shot™

Reduce cost of energy-efficient retrofits by 50% and decrease residents' energy costs by at least 20% within a decade.

# Fueling a Net-Zero Economy with Hydrogen

Hydrogen could be an important part of the pathway to net-zero carbon emissions, as it can be used in applications ranging from transportation to combined heat and power for buildings, from fertilizer production to steelmaking. This was noted in the Bipartisan Infrastructure Law which emphasized how hydrogen “plays a critical part in the comprehensive energy portfolio of the United States” and can be produced from a variety of clean sources, including renewables and fossil fuels with carbon capture utilization and storage.

Oklahoma, a renewable energy leader, is well-positioned to enable the hydrogen economy with state-of-the-art hydrogen production facilities, hydrogen-related equipment manufacturers, expansive water supplies, hydrogen-rich natural gas, long-standing gas transport infrastructure, and high CO<sub>2</sub> sequestration potential. Another key asset in the state is the hydrogen-related expertise, knowledge and resources found at The University of Oklahoma.

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## A Vision for OK’s Hydrogen Economy

A Hydrogen Production, Transportation, and Infrastructure Task Force was established by Oklahoma Senate Bill 1021 to study and submit a report laying out a statewide vision and roadmap for the economic development of hydrogen as a fuel source for transportation, industrial, commercial, and residential use. The report was co-authored by Task Force member and OU Vice President for Research and Partnerships Tomás Díaz de la Rubia with support from IREES reviewers.



## Symposium on Emerging Hydrogen Policy

The 2023 ONE J Symposium, held on April 22, was co-hosted by the OU College of Law and IREES. The event explored the development of policies and lawmaking frameworks related to hydrogen energy. Tim Filley moderated a roundtable discussion and presented “Hydrogen Energy 101,” an overarching view of the hydrogen economy and issues surrounding the emerging industry.

The roundtable included OU’s Li Song who shared her thoughts on technologies that enhance community resilience and energy efficiency; and Joyce Burch, director of the Office of Corporate Partnerships and Regional Economic Development, who presented a talk about commercializing university technology.

Aaron Collins, superintendent of Metro Technology Centers; James Grimsley, executive director of Advanced Technology Initiatives for the Choctaw Nation of Oklahoma; Sharon Harrison, CEO of Harrison Consulting; and Eric Pollard, air quality and clean cities manager at the Association of Central Oklahoma Governments, also participated in the roundtable and presented insights related to their professional experience.

## CHEPS — An OU Big Idea

In April 2023, OU's Carbon-Free Hydrogen Energy Production and Storage project (CHEPS) and IREES convened a two-day conference on campus focused on "The Hydrogen-Powered Future". The CHEPS project, led by Dimitrios Papavassiliou, professor of chemical engineering, and director of the School of Sustainable Chemical, Biological and Materials Engineering, was one of five Big Idea Challenge projects sponsored by the OU Office of the Vice President for Research and Partnerships. The team has worked together for 2 years developing a convergent approach to enable the transition to a carbon-free energy economy with an emphasis on hydrogen power.

In the keynote address, VPRP Tomás Díaz de la Rubia emphasized, "Today we're talking about energy, about hydrogen, but I also wanted to frame this conference around climate change. We're going to have to produce an enormous amount of energy over the next 20-30 years, and we must accomplish this while also mitigating climate change." Noting that 35% of this year's externally submitted energy research proposals targeted hydrogen, Tim Filley underscored OU's remarkable focus on this space.

## Low Carbon H<sub>2</sub> Tech: Teaming for DOE Proposal Development

The U.S. DOE announced its Hydrogen Earth Shot initiative in 2021, with the goal of reducing the price of clean hydrogen produced to \$1 per kilogram in one decade — the "1-1-1" goal. In August 2021, the Office of Basic Energy Sciences (BES) held a roundtable to discuss the scientific and technical barriers for carbon-neutral hydrogen production, storage, and utilization.

Using the report issued from this roundtable as a guide, IREES hosted a 2-day workshop in October 2022 bringing together faculty from across OU's campus to discuss interests and opportunities in foundational science topics related to carbon-neutral hydrogen technologies. Daniel Resasco, George Lynn Cross Professor in OU's School of Sustainable Chemical, Biological and Materials Engineering, and co-author of the DOE report, led the discussions. More than 35 faculty participated in the two day event.



Tomás Díaz de la Rubia, OU VPRP

## Hydrogen-Related Proposal Activity

Submitted research proposals encompassing the hydrogen economy represented the largest share of both requested funding at \$37 million and number of proposals submitted (20 submissions) in fiscal year 2023.

These proposals include fundamental research on hydrogen systems, such as the newly-awarded effort led by Steven Crossley, professor of chemical engineering in the School of Sustainable Chemical, Biological and Materials Engineering, and IREES associate director, to advance catalytic generation of hydrogen from natural gas and biomass streams while simultaneously producing high-value solid carbon products (funded by the US NSF).

Dimitrios Papavassiliou led a proposal focused on engaging local communities in the co-development of research goals related to the hydrogen energy transition (proposal submitted to the NSF).

Hydrogen proposals also focused on facilitating large-scale industry-university-government-community partnerships, such as the tri-state (AR-LA-OK) HALO Hydrogen Hub effort led at OU by PI Tim Filley to demonstrate regional deployment of existing hydrogen technologies in the marketplace.



# Research Highlights

Our overarching goal is to support research and creative activity that builds-in capacity to live and thrive with change — both gradual and abrupt — such that we can anticipate, prepare for, respond to, and recover from threats with minimum harm and maximum benefit to society, the economy, and the environment. Building on OU strengths, we have focused IREES efforts on three broad topical areas that include **Low-Carbon Energy & Infrastructure**; **Sustainable Societies**, and **Earth Systems & Global Change**. The following pages highlight examples of research papers and new grant activity across our key research focus areas.

## Reduction of microbial diversity in grassland soil is driven by long-term climate warming

The rapid loss of biodiversity due to human alternation of the global environment is threatening ecosystem functioning. Soil biodiversity is essential for maintaining the health of terrestrial systems, but how climate change affects soil microbial biodiversity remains elusive. By examining changes in microbial (i.e., bacterial, fungal, and protistan) diversity over time, a new study out of the research group of Jizhong Zhou, George Lynn Cross and Presidential Professor of microbiology in the School of Biological Sciences and director of the Institute for Environmental Genomics, provides explicit evidence that climate warming decreases microbial diversity via both reductions in soil moisture and enhanced microbial community

interactions under warming. The study, led by Liyou Wu, research scientist and adjunct professor, also revealed microbial biodiversity has strong linkages with various ecosystem functional processes. These results imply that the detrimental effects of biodiversity loss could be more severe in a warmer world, making ecosystems more vulnerable in the future.

Wu, L., Y. Zhang, X. Guo, D. Ning, X. Zhou, J. Feng, M. M. Yuan., S. Liu, J. Guo, Z. Gao, J. Ma, J. Kuang, S. Jian, S. Han, Z. Yang, Y. Ouyang, Y. Fu, N. Xiao, X. Liu, L. Wu, A. Zhou, Y. Yang, J. M. Tiedje, and J.-Z. Zhou. 2022. Reduction of microbial diversity in grassland soil is driven by long-term climate warming. *Nature Microbiology*, 7:1054–1062.



The research was conducted at the Kessler Atmospheric and Ecological Field Station in McClain County, Oklahoma. The field site experiment was established in July 2009 with a blocked split-plot design in which warming (continuous heating at a target of +3 °C above ambient temperature) and precipitation alteration (targets of -50% and +100% of ambient precipitation) were primary factors nested with clipping (annual removal of above-ground biomass at peak growth season) as the secondary factor.

# Methane leaks are a global challenge, OU researchers have solutions

Methane, the main component of natural gas, is a potent greenhouse gas, trapping 30 times more atmospheric heat compared to carbon dioxide. The oil and gas sector is the largest industrial source of methane emissions in the U.S. Responsible for ~30% of total emissions, the rapid and accurate assessment of the amount and location of methane releases from this sector is an essential part of slowing climate change, accelerating emissions mitigation technologies that enable a “leak-tight” natural gas value chain, and improving local air quality.

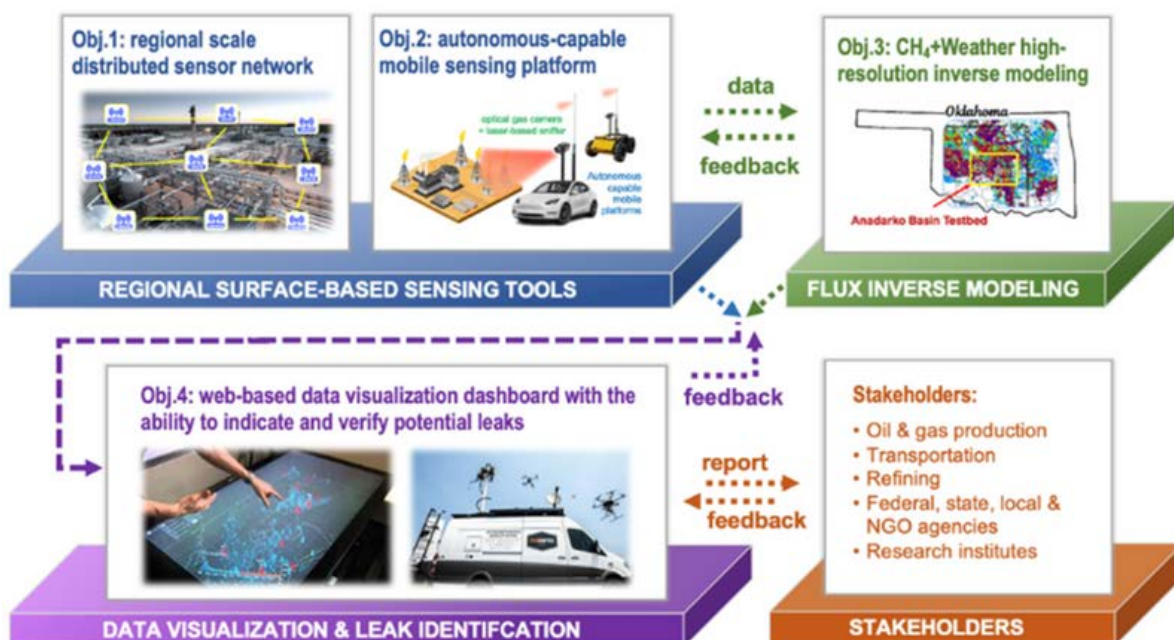
With over \$8M in funding from the U.S. DOE and university and industry partners, a new project led by Binbin Weng, assistant professor in the School of Electrical and Computer Engineering and IREES Faculty Fellow, is developing a scalable, integrated surface sensor network system that measures and monitors methane concentration and leak plumes in

the Anadarko Basin– one of the largest domestic sources of natural gas in the U.S.

The project integrates knowledge and expertise from engineering, physical science, education, and social science disciplines at OU, Penn State and the University of Science and Arts of Oklahoma; tribal governments; and industry partners. The team’s workforce development activities are focused on a student internship program with guided mentorship to careers in environmental monitoring, leveraging the OU iPath program, the IREES Just Transitions Assessment Platform (see page 19) and programing in the OU Native Nations Center and Center for Faculty Excellence.

“We can provide real-time methane detection over a large regional scale that is not otherwise possible from ground-based methods.”

Binbin Weng, assistant professor of electrical and computer engineering



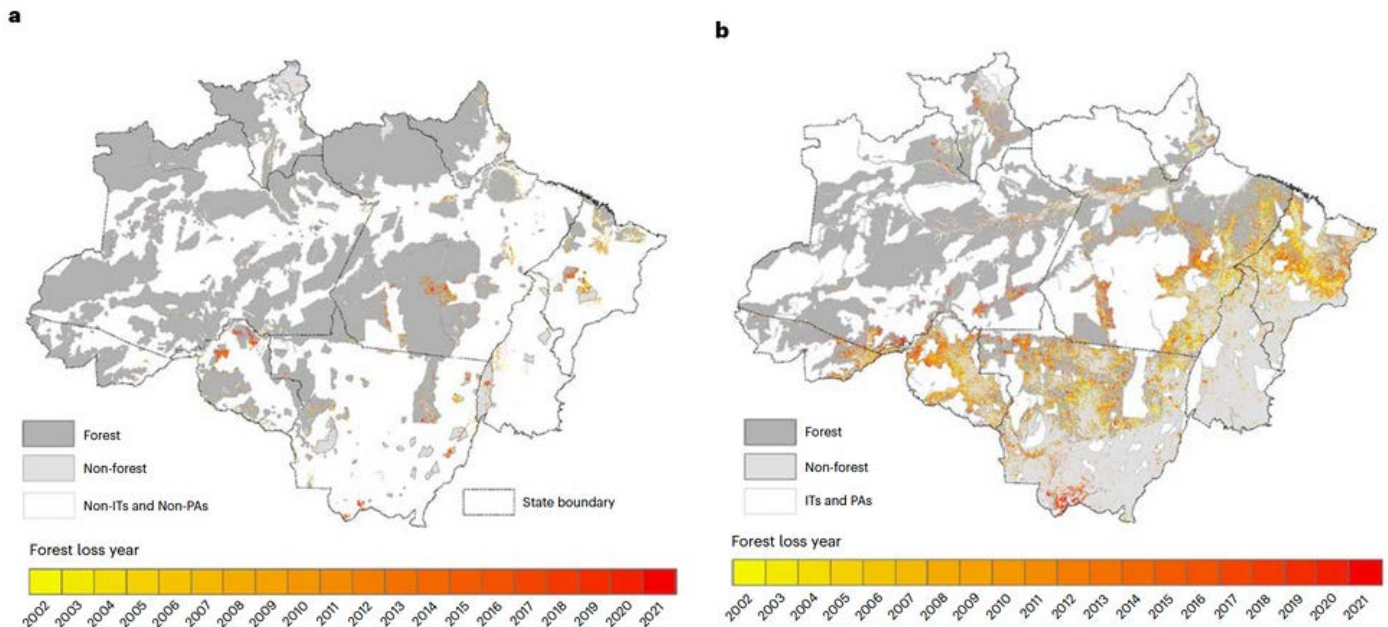
# Indigenous territories and protected areas are key to forest conservation in the Brazilian Amazon

The Brazilian Amazon (BA) has the largest tropical rainforest in the world, the highest biodiversity, and serves as a crucial carbon sink for the global climate. Forest conservation in the BA, however, has encountered increasing threats from loosened environmental laws and regulations, changing governmental policies and massive economic development – especially over the last ten years.

A research study led by Yuanwei Qin, research scientist in OU's Center for Earth Observation and Modeling (CEOM), analyzed time series satellite images from 2000 to 2021 to examine the role of Indigenous territories (IT) and protected areas (PA) in forest conservation in the Brazilian Amazon. The study team included Xiangming Xiao, George Lynn Cross Professor of ecology and remote sensing in the School of Biological Sciences, director of the CEOM, and associate director of IREES; Fabio de Sa e Silva, associate professor in the College of International Studies and Wick Cary Professor of Brazilian Studies; and collaborators from the Brazilian National Institute for Space Research and the National Institute for Research in Amazonia in Brazil.

Protected areas in the BA are subject to different state and national governance arrangements and have different management objectives, including strict protection or sustainable use. The researchers found that over the study period, areas classified as ITs or PAs increased to cover 52% of forested areas in the BA, while gross forest loss fell 48% in PAs subject to 'strict protection' and 11% in PAs subject to 'sustainable use.' However, from 2018 to 2021, a period of loosened constraints to the economic activities in the protected areas and incentives to expand agriculture, the percentage rate of annual gross forest loss in ITs and PAs was twice that of non-designated areas. The findings reveal the vital role and substantial progress achieved by ITs and PAs in Amazonian forest conservation as well as the dangers of recent weakening of Brazil's forest policies.

Qin, Y., Xiao, X., Liu, F., de Sa e Silva, F., Shimabukuro, Y., Arai, E. Fearnside, P.M., Forest conservation in Indigenous territories and protected areas in the Brazilian Amazon. *Nature Sustainability* 6, 295–305 (2023).



**Annual gross forest area losses in the BA from 2002 to 2021. a,** Spatial distribution of the year a forest pixel in 2001 was classified from forest to nonforest (forest loss) in the ITs/PAs. **b,** Spatial distribution of the year a forest pixel in 2001 was classified from forest to non-forest (forest loss) outside ITs/PAs.



# Demonstration of a solar-geothermal district system in the Citizen Potawatomi Nation

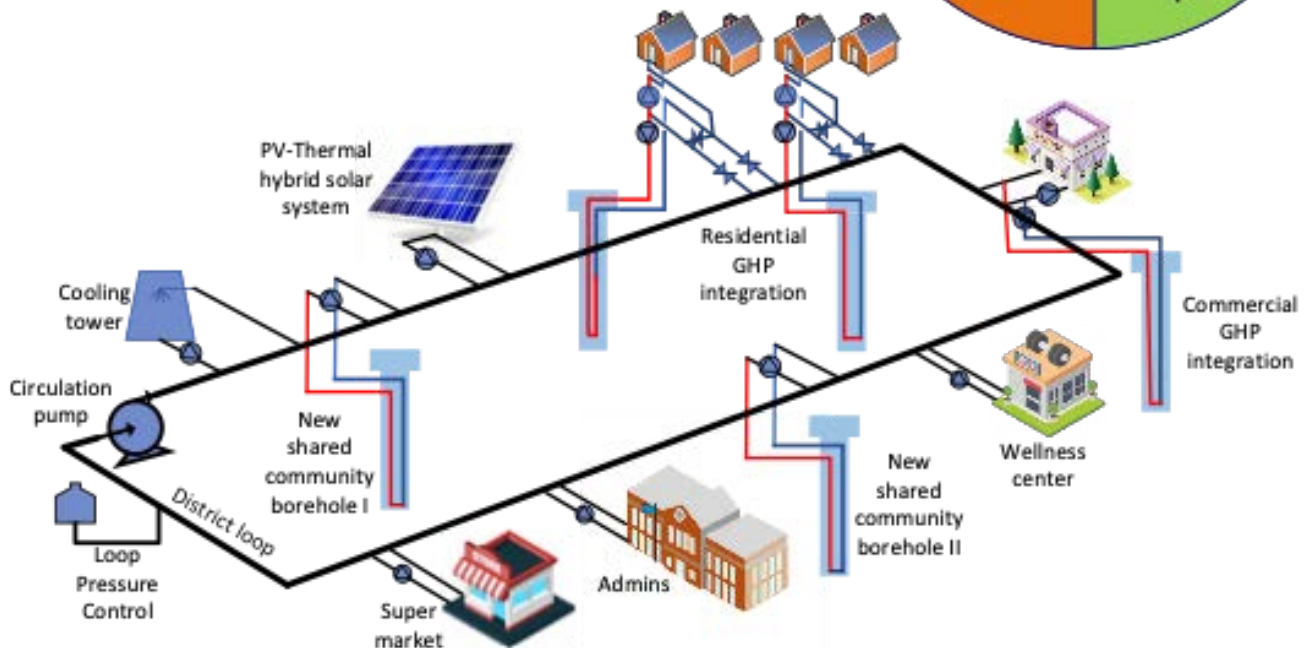
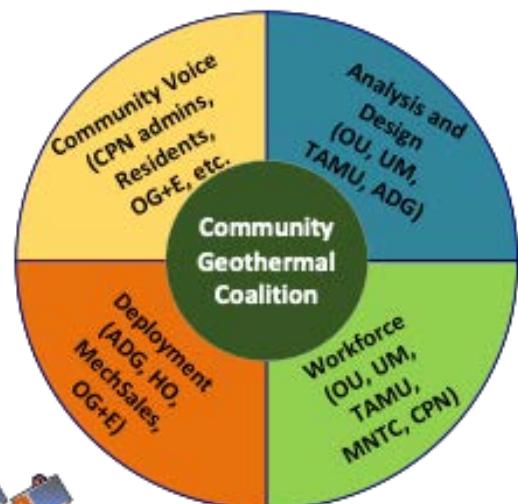
Geothermal district systems utilize the Earth's heat to provide heating and cooling to multiple buildings within a defined district. The key component of these systems is a network of underground pipes, known as a geothermal loop, which is connected to a central plant. This network carries a heat transfer fluid, such as water or an antifreeze solution, which absorbs the Earth's natural heat and transports it to the buildings.

A new project led by Li Song and co-developed with partners from the Citizen Potawatomi Nation, will demonstrate the performance of a solar-geothermal district heating and cooling (sol-GDHC) system with a single ambient temperature pipe loop and building-level electric-powered heat pumps in a tribal community where 82% of the space is currently served by gas and electric powered heating and cooling systems.

The project team will retrofit an existing tribal community with at least 50% heating and cooling loads served by the proposed GDHC system.

The team will validate the feasibility of the proposed concept and provide pathways for its deployment, develop a business model to be replicated by similar communities nationwide and create a work force transition and training plan.

The project team includes partners from Citizen Potawatomi Nation's Iron Horse Industrial Park , OG&E, Moore Norman Technology Center, ADG Architects, Mechanical Sales Inc., Harrison Orr Air-Conditioning LLC, Texas A & M University, University of Miami.



The sol-GDHC schematic

# Conversion of methane and biomass to hydrogen and high-performance carbon

Hydrogen is a clean-burning fuel producing only water as a by product. However, current economically viable methods for hydrogen production are energy-intensive and have a high carbon footprint. A new research project will bring together Oklahoma's abundant natural gas (methane) resources with Iowa's renewable biomass (e.g., crop waste, Miscanthus grass, wood chips) to create a better way to produce hydrogen.

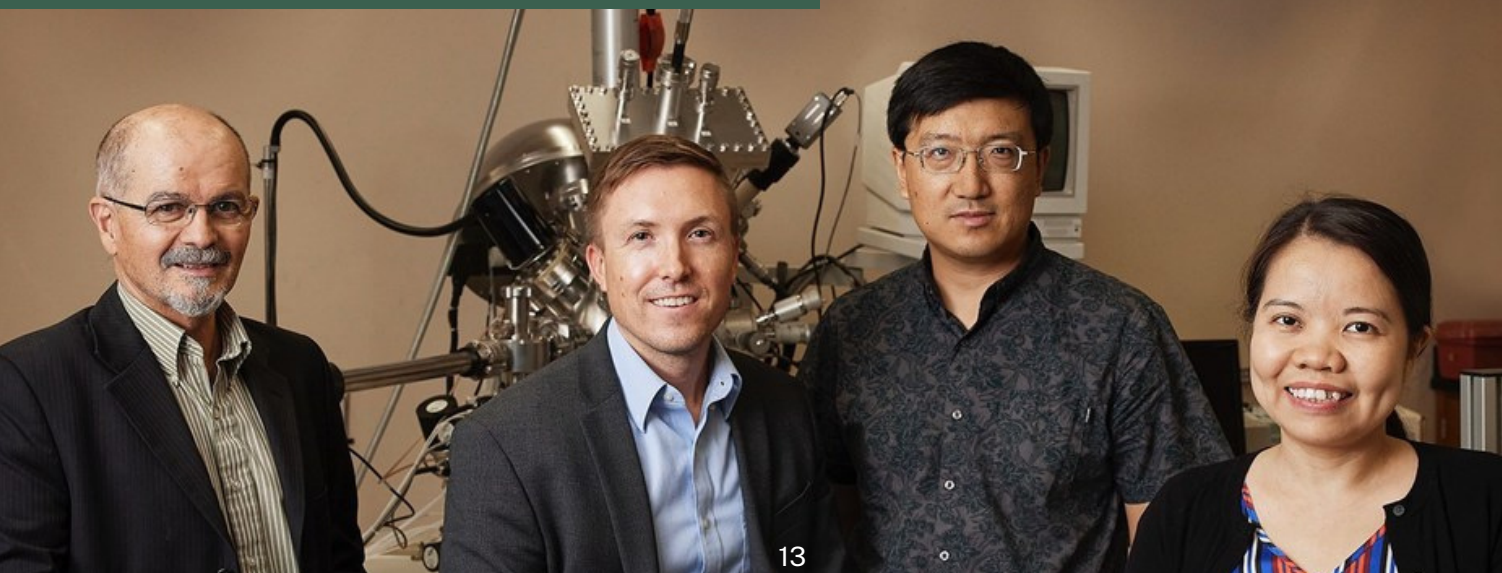
Led by Steven Crossley, with OU colleagues, School of Sustainable Chemical, Biological and Materials Engineering professors Bin Wang and Daniel Resasco, and assistant professor Ngoc Bui (School of Civil Engineering and Environmental Science) and Iowa State collaborators Jean-Philippe Tessonier, Mark Wright, and Eric Cochran, the research team will focus on optimizing a pyrolysis method that uses heat and a catalyst to split methane (and biomass) into hydrogen gas and solid carbon.

Unlike conventional methods of hydrogen production, methane pyrolysis produces hydrogen without any carbon emissions. The solid carbon produced in the process is also a potentially valuable by-product that can be used in many ways. The researchers will focus their efforts on 1) designing catalysts to lower the temperature needed to convert feedstocks, 2) optimizing hydrogen yields and catalyst regeneration, and 3) blending methane and biomass feedstocks to "tune" the properties of the solid carbon that is produced.

The team will integrate expertise in experimental and theoretical modeling with deep knowledge in materials synthesis and characterization, and will use machine learning and artificial intelligence methods to connect across modeling scales and predict promising surface structures. The four-year project is funded by a \$4 million grant from the National Science Foundation — and it could transform the way we produce hydrogen.

"We're combining two different regions with wildly different natural resources and we're creating new solutions that we believe will be synergistic."

**Steven Crossley, Sam A. Wilson Professor of chemical engineering; and IREES Associate Director**





# PERU-Hub: enabling sustainable agricultural development

Farmers in the Amazon region of Peru have limited access to agricultural innovation or new markets, and scarce opportunities for women and indigenous communities. They also lack access to reliable, actionable information, like real-time weather reports and soil quality and land use suitability maps, all of which impact their ability to adapt to regional stresses like climate change, severe weather, legacy land degradation, and socioeconomic pressures.

In response, a consortium of research institutions, led by the Universidad Nacional Agraria La Molina with partners from the University of Oklahoma, Purdue University, Utah State, Bioversity International, and the International Center for Tropical Agriculture, have launched the PERU-Hub project. Funded with a \$15 million grant from the US Agency for International Development, PERU Hub is expanding use-inspired research in sustainable agricultural development, creating technology transfer mechanisms, and supporting growth of entrepreneurship programs in the region.

The University of Oklahoma's contribution to the project is focused on developing an integrated soil-land use-weather monitoring network for the San Martin region. The network will be supported by the latest in real-time weather and soil data, citizen science-driven soil analysis, advanced remote sensing, digital mapping and visual analytics, and land suitability modelling. The team is also training soil health technicians who will distribute custom-built soil monitoring kits (Pacha Kit) to farmers and provide them with technical support so they can assess the soil health of their own land.

The OU team is co-led by Tim Filley and Brad Illston, senior research scientist at the Oklahoma Mesonet and Oklahoma Climatological Survey and the School of Meteorology. The OU team also includes David Ebert, professor of computer science and director of OU's Data Institute for Societal Challenges; Jennifer Koch, associate professor of geography and environmental sustainability; and Victor Maqqe, managing director of the Latin America Sustainability Initiative within IREES.

"Our overarching goal is to serve as a global model for research utilization, education, and knowledge-building in rural regions of developing countries."

**Tim Filley, professor and IREES director**



# Toward improved monitoring of the condition of lithium-ion batteries

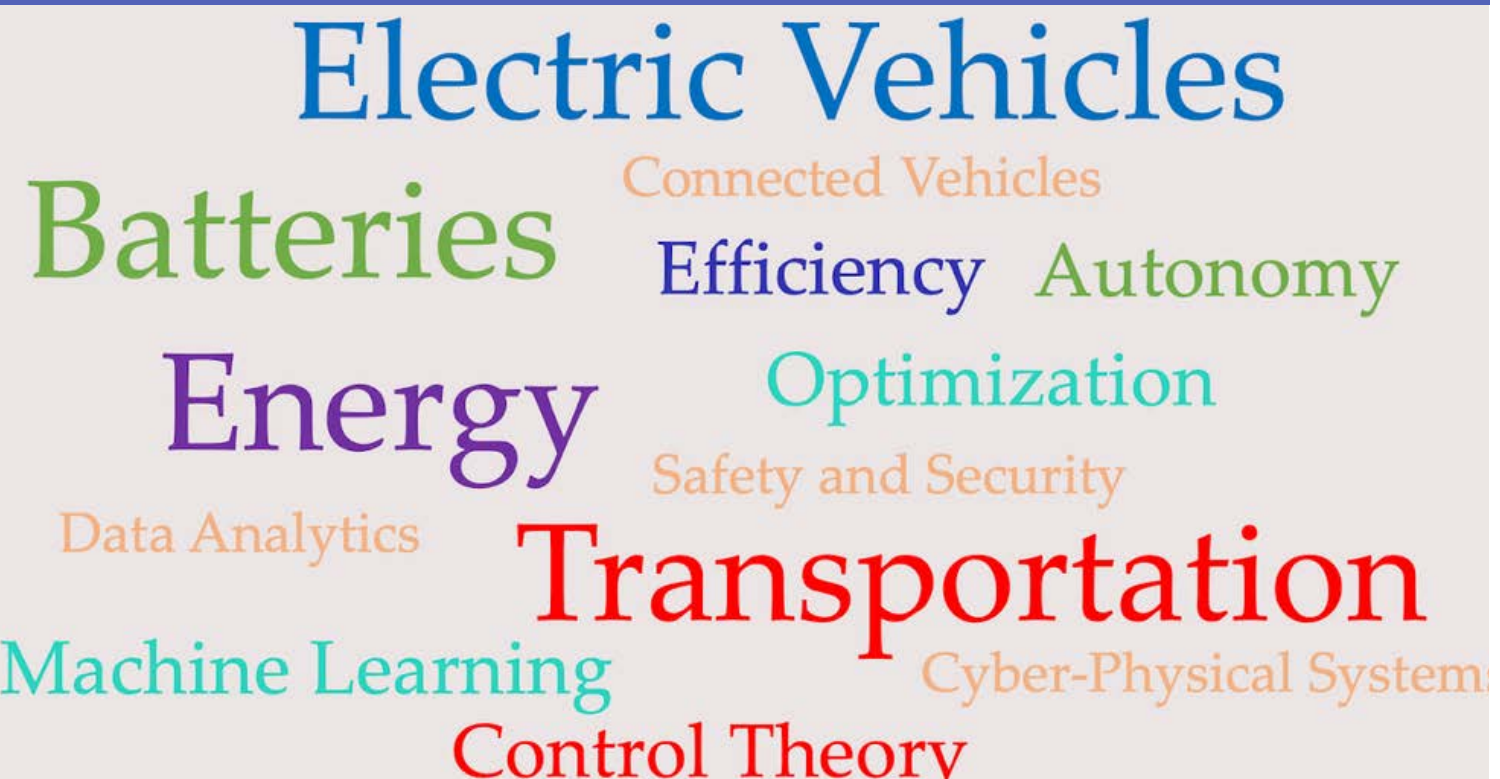
Batteries based on lithium-ion cells are used in many applications including electric and hybrid vehicles, renewable energy storage systems, and energy storage on the grid. Over time, and as the batteries charge and discharge, their storage capacity is reduced, affecting the lifespan of the lithium-ion cells and their safe operation. To assess the quality of these batteries their state of charge (SOC) and state-of-health (SOH) must be assessed. While SOC, the ratio of a battery's remaining charge to its rated capacity, indicates when a battery needs to be recharged, SOH provides an estimation of the battery's usable capacity, an indicator of how the battery is aging and degrading.

These different states cannot be directly measured during regular operation and must be inferred from various data. Current assessment methods, however, cannot pinpoint the physical sources leading to battery degradation.

A new paper led by Dong Zhang, assistant professor in the School of Aerospace and Mechanical Engineering, presents a mathematically elegant way to reconstruct specific battery electrochemical information, including the electrode level states, together with the electrolyte dynamics and amount of cyclable lithium. The new estimation framework can perform monitoring and diagnosis of battery charge and health down to the level of individual electrode and the electrolyte, greatly improving battery management systems.

D. Zhang, L. D. Couto, S. Park, V. Viswanathan, S. Moura. Beyond Battery State of Charge Estimation: Observer for Electrode-Level State and Cyclable Lithium with Electrolyte Dynamics, IEEE Transactions on Transportation Electrification (2023).

Research in the Zhang group is focused on developing battery monitoring and control software to improve the capacity, safety, and charge rate of electric vehicle batteries.





# Collaborating for equity-focused transportation research and workforce development

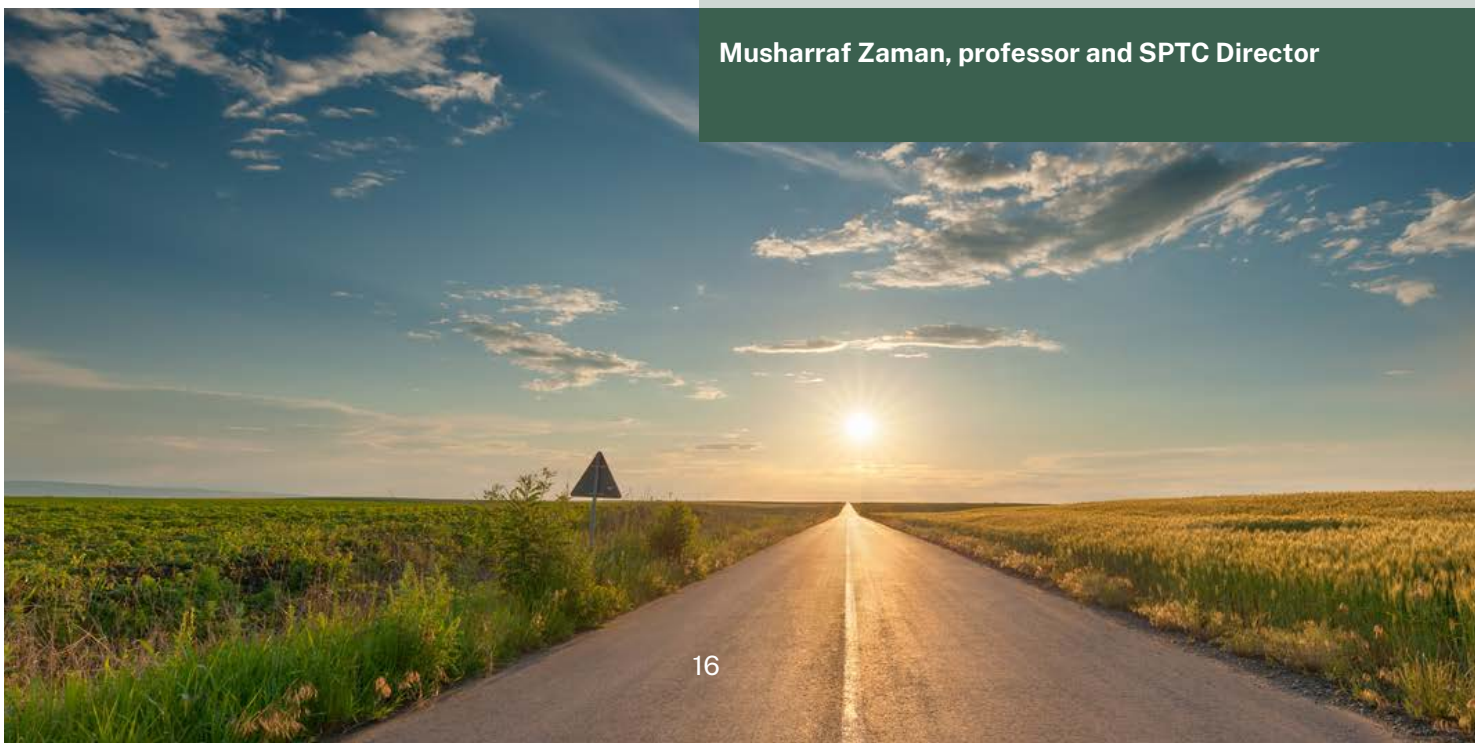
In early 2023, the U.S. Department of Transportation (USDOT) selected the University of Oklahoma led Southern Plains Transportation Center (SPTC) to serve as the Region 6 Regional University Transportation Center (UTC). With a five-year, \$15 million grant from the USDOT and \$5 million grant from the Oklahoma Department of Transportation, the five-state SPTC will address climate-related transportation challenges across the region. The center, led by Musharraf Zaman, David Ross Boyd Professor and Aaron Alexander Professor of civil engineering and Alumni Chair Professor of petroleum engineering, includes researchers from four OU colleges and 11 diverse external academic institutions — each with demonstrated expertise in addressing weather-related infrastructure and durability issues — and strong connections with state departments of transportation, private stakeholders, and other partners. With 69 tribes, sizable rural and coastal areas (>6 million rural lane miles), and a disproportionate number of underserved communities, Region 6 is fertile ground for infusing equity and environmental justice in UTC activities.

A strong supporter of the SPTC, IREES has facilitated partnerships with Choctaw Nation and Citizen Potawatomi Nation, and new connections with leaders in the Oklahoma automotive industry and other stakeholder groups. To grow the SPTC-IREES partnership, Royce Floyd, associate professor in the School of Civil Engineering and Environmental Science and SPTC associate director, has been appointed a 2023 IREES Faculty Fellow. Over the next year, he will work on developing equity-focused projects connecting resources, partnerships and expertise across IREES and the SPTC.



“The partnership with IREES was critical in helping to secure the grant, and will be instrumental in expanding opportunities going forward.”

**Musharraf Zaman, professor and SPTC Director**



# Supercharging Research with Infrastructure Investments

OU's collection of field stations, laboratory facilities, supporting instrumentation, distributed monitoring networks, and expert technical staff supports a vibrant research ecosystem. Each year IREES invests in infrastructure that supplies high-quality research, develops knowledge to address key societal challenges and business sector needs, and creates a framework for learning, workforce development, and innovation.

## The Kessler Atmospheric and Ecological Field Station

IREES investments in the Kessler Atmospheric and Ecological Field Station (KAEFS) include a new soil sensor network that measures temperature, soil moisture and conductivity. IREES also funded a study to map the area's land use and land cover (LULC) change over the past century — an analysis that has never been done for KAEFS. Bruce Hoagland, professor in the Department of Geography and Environmental Sustainability and IREES Faculty Fellow, and graduate student Adam Anwar are leading the study, documenting the physical changes in the landscape from the 1870s to the present.

This analysis will ultimately allow researchers conducting experiments at KAEFS to understand legacy controls on modern processes and patterns across the landscape — an often neglected but critically important facet of landscape ecology and biogeochemistry. Initial work digitizing and georectifying plats from the late 1800s and aerial photographs of the field station from the U.S. Department of Agriculture (1930s-1969) has been completed.



### A world-class but largely 'invisible' research gem

OU's KAEFS is located in the rolling hills of the Permian Redbed region of Central Oklahoma, about 20 miles southwest of the Norman campus. Within its 360 acres, the field station supports a diverse vegetation dominated by grasslands on the slopes and hilltops and riparian woodlands around streams and creeks in the lowlands.

KAEFS is home to many long-term meteorological and biological experiments focused on integrated studies of atmospheric, ecological, and human interactions. This work contributes to our understanding of how the region is changing and will help us better predict the future of the many critical services these landscapes provide to all of us in Oklahoma and beyond.



# Stable Isotope Measurement Facility

Over the last two years, space in the Stephenson Research and Technology Center on the OU Norman campus has been renovated to create Oklahoma's premier stable isotope measurement facility, extending a long tradition of OU leadership in isotope analysis. Stable isotope spectroscopy is among the most powerful tools used to interrogate the Earth's composition, history, and processes. The natural distribution of stable isotopes in plants, rocks, water, and animals are reflective of the physico-chemical properties and processes at play in nature and are used to model and quantify natural systems. Isotope mass analysis is also a common tool used in microbiology, medicine, and chemistry. Stable isotope tracers--compounds that are artificially enriched in a particular isotope— are often used in conjunction with molecular biology tools to yield in-depth assessment of metabolic processes.

The new lab, a light element (H,C,N,O,S) stable isotope (e.g.  $^{12}\text{C}$  vs  $^{13}\text{C}$ ) measurement facility is near completion and expected to be fully operational in early summer 2024. Jani Sparks, a stable isotope specialist, was recruited to OU to help Tim Filley build and manage this core research infrastructure, which will serve OU and external clients.

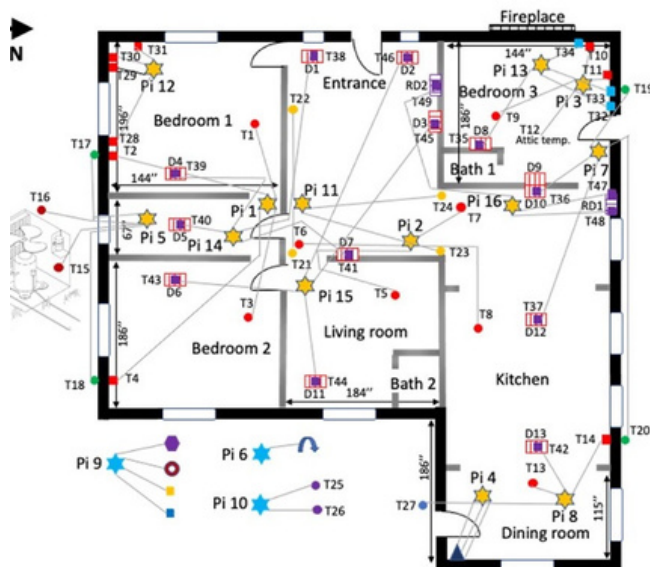


**ABOVE:** Construction of the Stable Isotope Measurement Facility is nearly completed.

# The Smart House Lab

Smart homes contain “smart” versions of common appliances and systems such as thermostats, light switches, locks, doorbells, and shades. What makes a particular device smart is its connectivity, either to the internet, other devices, or both, which allows for remote monitoring and management of the appliances/system; and its “intelligence.” Smart devices, embedded with sensors and software-powered artificial intelligence, can understand the environment they're in and react in a pre-specified way, facilitating the daily tasks and comfort of residents, improving energy efficiency and even energy consumption planning.

Recognizing the research needs and opportunities related to energy systems in smart homes, Li Song established the Smart House Lab to create a platform for these studies. Rented from OU with support from IREES, Li outfitted the 1,658 ft<sup>2</sup> house with 50+ channels of sensors collecting data at 30 second intervals through a cloud-based acquisition system. With finding from the U.S. DOE and other agencies, Li, her students, and collaborators are using the sensed environment to create energy optimization models and provide a testbed for energy efficient heating and cooling systems.



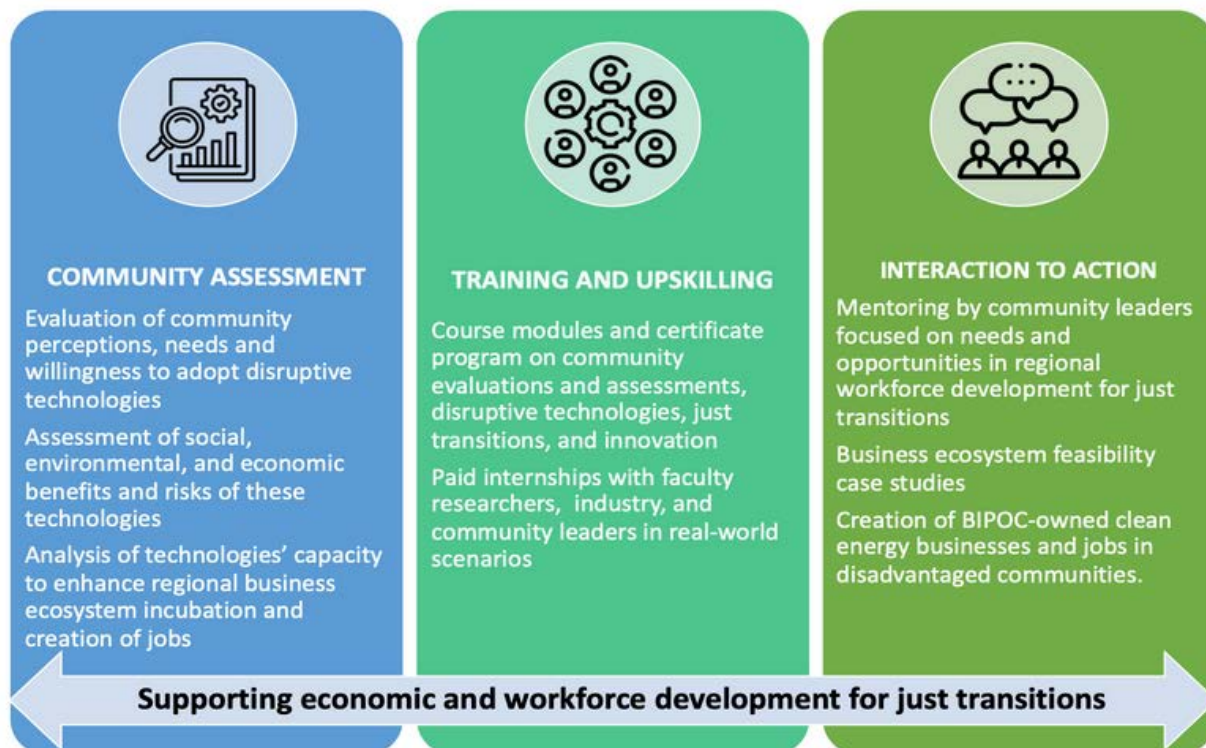
# Excellence in Education

## The Just Transitions Assessment Platform

Just transitions toward a low-carbon, climate-resilient future require balancing complex trade-offs between economic, social, and environmental concerns. However, historic patterns of environmental injustice, among other factors, have already resulted in disproportionately disadvantaged communities — communities exposed to environmental harm while also excluded from the benefits of new technologies. These inequalities must be considered to ensure that as we move toward a low-carbon economy we do not create or exacerbate injustices.

Developed by IREES, the Just Transitions Assessment Platform (JTAP) is a student-centered framework that builds capacity to 1) assess how the regional deployment of new technologies impacts communities, and 2) accelerate investments in the technologies that strengthen communities. An overarching emphasis is placed on understanding the importance of inclusive decision-making and fair distribution of benefits and burdens when considering new technologies. The technologies considered span across sectors from energy to manufacturing, from housing to transportation.

The JTAP helps advance just transitions by centering disadvantaged communities as critical partners in our efforts to create a diverse, talented workforce. We partner with Tribal Nations, the OU Center for Faculty Excellence, the Native Nations Center, Oklahoma CareerTech, minority-serving institutions, and historically black college and universities to recruit a diverse group of students to the program. Additional partners include the Oklahoma Alliance for Geographic Education who are translating some JTAP efforts to students and educators in the K-12 classroom.



JTAP revamps education, training, and partnership models to prepare individuals and at-risk communities for technological disruption as societies transition toward low-carbon, high-tech economies.



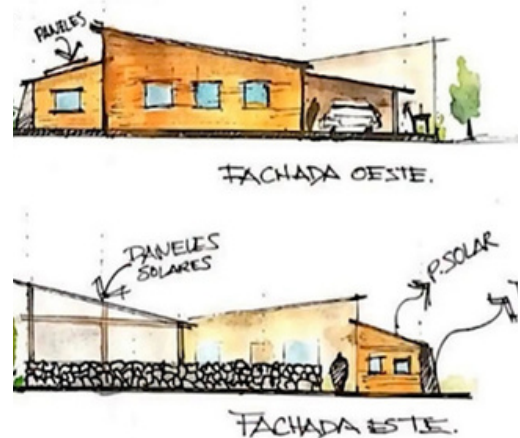
# Innovations in student service-learning: sustainable, affordable, high-altitude housing

In the high-altitude region of Puno, Peru, the temperature at night drops to 0°F between May and October. For poor households, that translates to nighttime indoor temperatures in dwellings as low as 32°F. Low indoor temperatures are related to cardiovascular problems, extreme discomfort, and respiratory infections. Indoor air contamination from poorly ventilated cooking smoke exacerbates health problems, especially among children and the elderly.

An international research collaboration is taking an innovative bi-lateral undergraduate student service-learning design approach to address these challenges. The project, co-led by the University of Oklahoma's Ben Bigelow, associate professor in the Christopher C. Gibbs College of Architecture, and Victor Maque brings together teams of students and faculty from OU with those from the Universidad Nacional del Altiplano in Puno through connected training in both U.S. and Peruvian campuses. The teams combine traditional knowledge and local materials with advanced technologies to design and build a sustainable and affordable model house in

Puno Peru — the Inti Wasi (House of the Sun, in the native Quechua language). The “Inti Wasi” prototype will be built on the UNAP campus near the existing dormitories to allow for its use as student housing, long-term monitoring of the house's performance, and for future iterations and improvements to its design and function.

The project is funded through a grant from the 100,000 Strong in the Americas Innovation Fund, which supports innovative, inclusive training and exchange programs for students and faculty in strategic areas, including climate solutions and sustainable energy.



“The project is an exciting opportunity for students have hands on experiences with a combination of innovative and traditional building science principles, things they would only learn in theory here on campus.”

**Ben Bigelow**, associate professor in the Haskell and Irene Lemon Construction Science Division



# Inaugural energy workshop for National Defense University students and instructors

Students, staff, and faculty at IREES hosted a group from the National Defense University (NDU) for an intensive immersion in hydrogen and geothermal technologies, power grid integration, and hydraulic fracturing. Over two days, 16 master's degree students and their instructors attended panel presentations and Q&A sessions with OU energy faculty, toured OU's energy-related laboratories, and explored research field sites in Oklahoma.

NDU, a higher education institution funded by the U.S. Department of Defense, facilitates education, training and professional development of national security leaders. This visit to OU, the first of what will be an annual event, supplements NDU's energy curriculum with a focus on new and emerging energy technologies .

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**“As a higher education institute, we are proud to provide first-hand learning opportunity to NDU graduate students. It also allows us to showcase leading-edge energy research at OU.”**

— Li Song, Professor and IREES Faculty Fellow

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The participants included 18 students and mentors who are either officers or federal employees in the U.S. Department of Defense (U.S. Navy, U.S. Army, Air Force, Coast Guard, the Defense Security Cooperation Agency, and the J8 Force Structure, Resources, and Assessment Directorate); the U.S. Department of State (Foreign Service, Agency for International Development) or the U.S. General Services Administration. The visiting scholars included two international students who are military officers from Colombia and Indonesia.



Photos from top to bottom: Professors Steven Crossley and Li Song with NDU students after touring several labs in Sarkey's Energy Center; Professor Runar Nygaard, Director of the Mewbourne school of Petroleum and Geological Engineering and the Eberly Family Chair of Petroleum Engineering answers questions about geothermal energy; students visit Professor Pejman Kazempoor's (School of Aerospace and Mechanical Engineering) hydrogen combustion and fuel cell technology labs; and Professor Rouzbeh Moghanloo (Mewbourne school of Petroleum and Geological Engineering) leads a tour of a fracking site in Grady, OK.



# Faculty dialogues: catalyzing an OU hydrogen curriculum

Held over two half-day sessions on March 9-10, 2023, IREES, in partnership with the Gallogly College of Engineering and the Mewbourne College Earth and Energy, facilitated discussions exploring new ways of organizing and connecting educational resources on hydrogen-related topics. The sessions provided an opportunity to review the current state of hydrogen educational offerings at the University of Oklahoma, consider how to organize for greater impact, and engage in discussions with workforce development stakeholders. More than 25 faculty from across campus, representatives from Oklahoma's Onward OKC CareerTech Compact, and senior graduate students participated in the sessions.

John W. Sheffield, president of the International Association for Hydrogen Energy, professor at Purdue University, and a 2023 IREES Energy Scholar, gave a framing seminar each day, including a presentation summarizing current challenges in "green" hydrogen generation.

The talks were followed by two sequential, facilitated break-out sessions. Breakout sessions following seminar 1, led by Baharak Sajjadi, assistant professor in the Mewbourne School of Petroleum and Geological Engineering, focused on building an integrated learning and research ecosystem for hydrogen energy. Seminar 2 breakout sessions, led by Tim Filley, explored opportunities to engage industry, international associations, national laboratories and other stakeholder institutions.

"When we start thinking about a hydrogen economy, organizations need to scale up and improve their green hydrogen design to meet market demands. That means we need to overbuild so that we have the renewable electricity to produce green hydrogen."

John Sheffield, Professor and 2023 IREES Energy Scholar



# Summer school for research excellence

IREES convened its first Latin America Sustainability Summer School on OU's Norman campus, welcoming a group of 17 faculty and students from the Universidad Nacional de San Agustín (UNSA) in Arequipa, Peru, for a week of technical training and research development activities focused on pressing climate change and human health challenges facing the Arequipa region.

From July 31 through August 7, 2022, attendees participated in technical workshops covering a wide range of subjects that include: health informatics, image processing, carbon nanotube fabrication, advanced treatments for cancer, regional climate modeling, hydrological modeling, theories in public policy, and collective decision making. The summer school also included plenary sessions designed to share cross-discipline perspectives, facilitate exploration of new approaches to addressing the regional impacts of global challenges, and social events to celebrate and strengthen connections.

The UNSA-OU partnership is administered through the IREES Latin America Sustainability Institute and co-led by Eveling Castro Gutiérrez, UNSA professor of computer science and Tim Filley. LASI partnerships and projects in Peru are designed to bridge use-based science and policy with resilient design in a university-led framework. Each effort is initiated by co-development of targeted knowledge and infrastructure needs to support a network of interrelated, interdisciplinary research projects addressing local and regional challenges. Read more about the UNSA-OU partnership on page 30.





# Fostering Partnerships & Catalyzing New Ideas



## Collaborating on air quality monitoring

A team of OU researchers including Tim Filley; Caitlin Hodges, assistant professor in the School of Geosciences; and Brad Illston, along with colleagues from the University of Science and Arts of Oklahoma, have partnered with the air quality team from the OK Department of Environmental Quality to expand the Oklahoma Christian University Air Quality Monitoring Super Site in a collaborative monitoring program for OKC.



## OU-ORNL Energy Decarbonization Workshop

In December 2022, IREES hosted a workshop exploring potential research collaborations between OU and Oak Ridge National Lab (ORNL) with two goals in mind: 1) facilitate introductions to get to know the scientific expertise, skills, and research assets of both institutions, and 2) identify common areas of interests within four broad topics. The topics covered in the workshop include: Carbon Capture, Utilization, and Storage; Community Benefits (DEIA, Justice 40); Energy Innovations in Transportation; and Hydrogen Generation, Storage, Transport, Utilization. Facilitated by Steven Crossley, the workshop established working groups for each topic to continue discussions.



## Catalyzing conversations on climate change and environmental justice

Kathleen Johnson, associate professor of Earth System Science at the University of California, Irvine, and member of the Anishinaabe; Grand Traverse Band of Ottawa and Chippewa Indians, spoke with nearly 100 students, faculty and staff during her visit to OU for seminars jointly sponsored by IREES and the School of Geosciences. She delivered two talks, one focused on tropical hydroclimate dynamics and the second on the role of STEM in advancing climate and environmental justice in Indigenous Communities. Professor Johnson also sparked discussion around the concepts of decolonizing science, original land acknowledgements, and respect for Indigenous knowledge using the guiding framework of the 'Four Rs' — reciprocity, relevance, responsibility, and respect.

## IREES partnership with Oklahoma Career Tech Center

In the Spring of 2023, IREES facilitated an MOU between the University and the Oklahoma Career Tech Center members of the ONWARDOKC Compact. The MOU articulates mechanisms to jointly pursue development of talent and training programs related to jobs supporting low-carbon technologies for energy production, storage, and use. Additional areas of emphasis include environmental programs for monitoring fugitive gases and atmospheric particulates.

The Compact — Canadian Valley Technology Center, Metro Tech Center, Mid-Del Technology Center, Moore-Norman Technology Center, and Francis Tuttle Technology — provides education and training to a diverse group of students, of which 53% are from minority populations.

In 2023, leveraging this MOU, IREES-affiliated research teams partnered with Compact members on energy-related proposals to federal funding opportunities with a total request in excess of \$20M.



For over 100 years, the Oklahoma Career Techs have been leaders in apprenticeship and training programs. In 2022 alone, the Compact delivered over 275,000 training hours to more than 1,500 companies.

This partnership greatly expands OU's capability to develop research programs with strong community benefit through workforce development at multiple entry levels to the workforce, complementing OU's existing capabilities at the undergraduate, graduate, and postdoctoral levels.

## Partnership with Madrid Polytechnic University

Pillar 5 in OU's Lead On Strategic Plan calls us to "Enrich and positively impact Oklahoma, the Nation, and the World through research and creative activity." Moving the needle on this goal requires strong international partnerships. In 2023, IREES facilitated an MOU between OU and one of Spain's premier engineering universities, the Universidad Politécnica de Madrid (UPM). UPM is also the No. 1 ranked science and technology university in the Spanish-speaking world.



The MOU lays out areas of cooperation including student exchanges, joint research and training programs, and a visiting scholars program. To initiate collaborations, Tim Filley and Steven Crossley, along with UPM counterparts, convened a hybrid workshop focused on hydrogen generation from renewable sources, waste plastic and biomass upcycling, and mining. Sixteen OU faculty participated in the workshop and presented research interests in radar innovation, the hydrogen economy, greenhouse gas and environmental monitoring, meteorology and climate research, and geothermal energy. For 2024, Crossley will lead a graduate student research exchange in support of existing federally-funded projects.



## White House Forum on Campus and Community-Scale Climate Change Solutions

IREES director Tim Filley represented Oklahoma at the March 2023 White House Office of Science and Technology Policy forum on leveraging the capabilities of colleges and universities from each state to catalyze climate solutions in communities across the country. Participants shared success stories and discussed campus innovations, community engagement, and inter-campus coordination, as well as new opportunities created by the Bipartisan Infrastructure Law and Inflation Reduction Act.



## OU at the U.S. Global Leadership Coalition Expo in Oklahoma City

With a strong and growing coalition in Oklahoma, the U.S. Global Leadership Coalition works to educate and engage policymakers and community leaders on why investments in development and diplomacy help keep America safe and strengthen Oklahoma's economy. In August 2022, the USGLC hosted an Expo and Town Hall with U.S. Rep. Stephanie Bice. The Expo highlighted how the U.S. government, NGOs, and corporations are working together to advance America's economic prosperity and national security, featuring local government, university, and business leaders from the region, including Tim Filley and LASI managing director Victor Maqque.



## Toward the United Nations Sustainability Goals

More than 80 people gathered for a campus-wide Sustainability Forum on the OU campus on January 28, 2023. The forum was convened to identify ways to overcome current technological hurdles, maintain a diverse, inclusive, and equitable society and achieve a better, more sustainable world. The event, organized by Alberto Striolo, the Lloyd and Jane Austin Presidential Professor in the School of Sustainable, Biological and Materials Engineering, and co-sponsored by IREES, included panel sessions focused on the social aspects of sustainability, technical research on sustainability, industrial approaches to sustainability, and outlooks on sustainability.





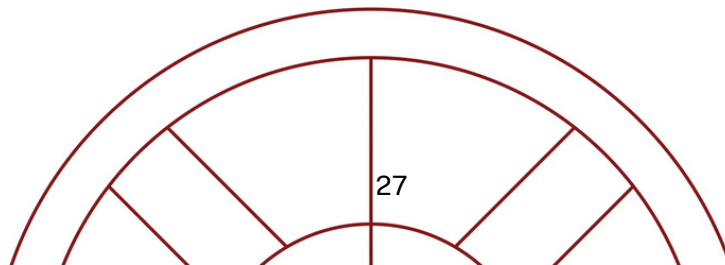
# Latin America Sustainability Initiative

Trust. Cooperation. Respect. Integrity. Mutual Benefit. Forward-thinking.

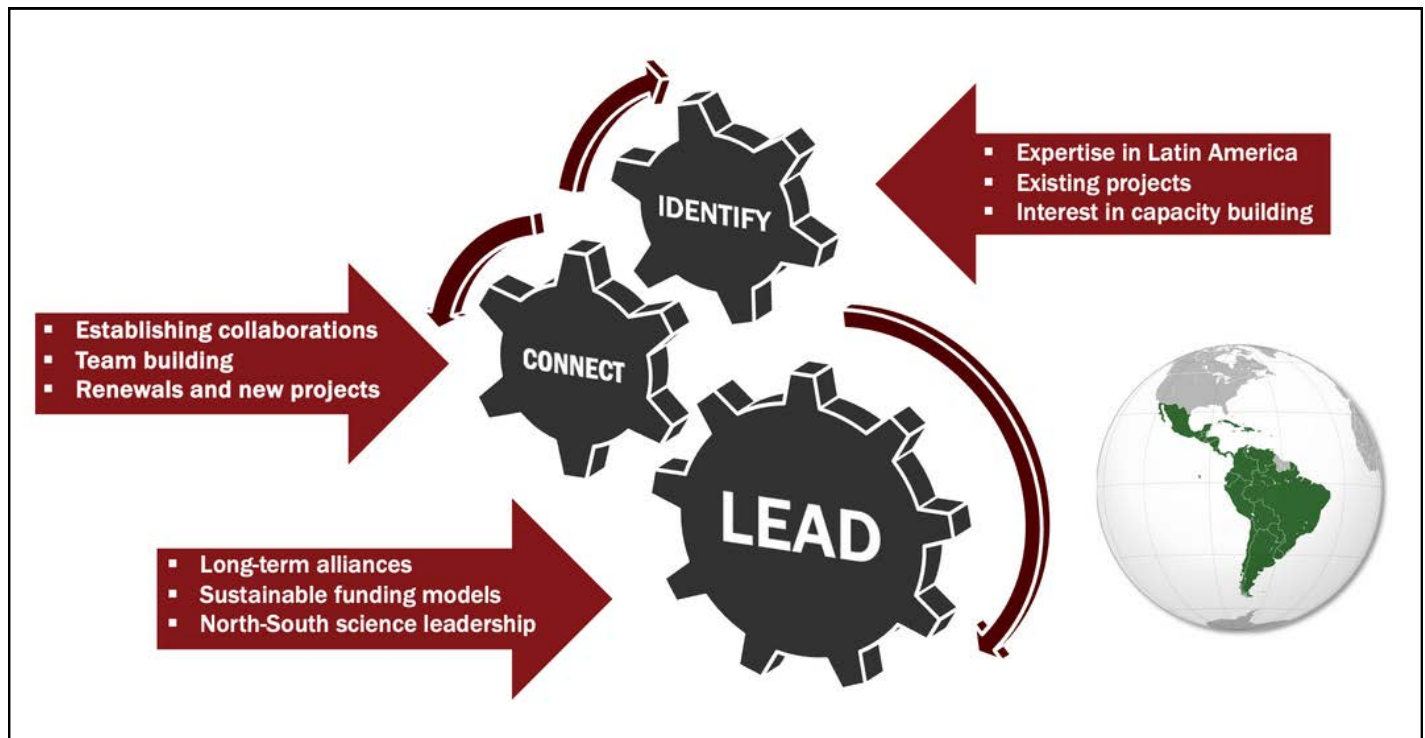
IREES established the Latin America Sustainability Initiative (LASI) in 2022 to catalyze, support, and scale collaborations with partners in Latin America to address complex environmental, human health, and societal challenges across the hemisphere. LASI connects universities, companies, research institutions, non-profit organizations, and government entities to identify sustainable development challenges and build interdisciplinary, inclusive teams to work on solutions that improve human well-being and the environments in which we live. We believe research universities are critical to building a vibrant innovation economy and are fundamental to regional geopolitical stability.

**Our long-term vision is to realize a vital, university-led research, education, and innovation network across the Americas that enables a sustainable, resilient, and equitable future.**

Our leadership team brings decades of experience and demonstrated success in forging deep relationships and intercultural connections to tackle tough challenges. We believe that research universities bring a unique collection of benefits to the table that includes regional trust capital, long-term workforce development, convergent research and development, and connected stakeholder networks.



# The LASI Approach: Identify, Connect, Lead



## Meet LASI Managing Director Victor Maquette

Victor Maquette serves as LASI managing director where he oversees the initiative's day-to-day operations, new partnership development, and team coordination. He is a faculty affiliate in the OU Department of History and a Latin America scholar with deep expertise in the social history of Andean communities, Andean ethnohistory, and the political, environmental, language and cultural views and practices of indigenous communities. His work spans across research centered on the impacts extractive industries have on local communities to the region's interconnected environmental, human health, and societal challenges.

With more than 10 years of experience in helping build research and education partnerships between U.S. and Latin American universities, Maquette strives to establish dynamic collaborations that focus on knowledge sharing and technology transfer, with effectively mentored capacity and capability development.

Maquette earned a Ph.D. and M.A. in the history of Latin America from the University of Notre Dame in South Bend, Indiana. He earned a B.A. and M.A. in Social Sciences at the Universidad Nacional del Altiplano in Puno, Peru.



## Peru in Focus

The nation of Peru has some of the greatest geographic, climatic, botanical and cultural diversity on the planet. It is also among the world's most climate-change vulnerable countries. The ability to conduct research within such diversity provides OU researchers unique opportunities to understand global controls on complex socioecological and economic grand challenges. However, the convergence approaches and meaningful engagement needed to do so successfully require strong partnerships with Peruvian communities and local institutions.

Under IREES, and with the creation of LASI, OU has expanded its university-to-university research and teaching MOUs from one to six and is pursuing over \$9.5 M in new research contracts with those partners. These proposed research collaborations involve faculty from across OU and cover topics such as hydrology, human health, soil health, mining contaminant mitigation, meteorology, climate change, water quality, and land cover/land use modeling.



## Current collaborations



The Peruvian Extension and Research Utilization Hub (PERU Hub), a \$15M, five year USAID-funded partnership of U.S. and Peruvian universities, is our core activity in the San Martín Peruvian rain forest. The OU team, co-led by Tim Filley and Brad Illston is creating an integrated soil and climate monitoring and decision support system for the **San Martín region** to improve sustainable use of soil and enhance productivity and profitability of farmers. Read more about the project, led by our partners at the Universidad Nacional Agraria La Molina in Lima, Peru, on page 14.



The partnership between OU and the Universidad Nacional de San Agustín is centered around a supportive framework that facilitates research collaborations in key areas defined by needs in the **Arequipa region** of Peru. Existing projects are focused on building resilience to climate change, advancing One Health, and designing adaptive social systems. Read more about the team's progress to date on pages 23 and 30.



Work in the **Puno region** of Peru includes a bilateral exchange program designed to facilitate collaboration between OU and the Universidad Nacional del Altiplano (UNA) of Puno to develop programs in the areas of environmental and human health. Three initial research projects focus on climate and hydrologic modeling; water quality monitoring; and sustainable development in the context of current drought. Funding for these projects is under negotiation. A separate education project led by Ben Bigelow and Victor Maqqe has already been funded (see page 20).





# The Global Change & Human Health Institute: A framework for the UNSA-OU Partnership

The Global Change and Human Health (GCHH) Institute is a framework designed to facilitate collaboration between OU and the Universidad Nacional de San Agustín (UNSA). This bold new partnership, co-directed by UNSA's Dr. Eveling Castro and OU's Tim Filley, aims to create a research, education, and innovation ecosystem where teams of faculty, students, and stakeholders from the public and private sectors work together to address social, economic, environmental, and technical challenges.

Seeded in 2021 with a grant from UNSA, the GCHH Institute is located on the UNSA campus in Arequipa, Peru, and administered jointly by the Office of the Vice Rector for Research at UNSA and OU's IREES through LASI. This novel arrangement facilitates co-development of the research, administrative, and technical infrastructure needed to support multi-year collaborations and further strengthen cross-cultural ties that are essential for advancing the Institute's mission.

The four OU-UNSA research projects are co-led by UNSA and OU professors Ming Xue, Roger Harrison, Javier Jo, and Hank Jenkins-Smith. Highlights from these collaborations include the 4 peer-reviewed publications (right) and the following:

- 11 conference presentations
- 28 online seminars
- 9 UNSA student research theses
- 12 visiting scholars hosted at OU
- 34 technical workshops in Peru

The GCHH Institute currently focuses efforts in three key areas, each supported with center-level infrastructure: building resilience to climate change, advancing One Health, and designing adaptive social systems. These three centers and a network of four interrelated and interdisciplinary inaugural projects were launched with bold ambition — to enhance UNSA's research and educational capacity, improve regional decision-making, increase protection and sustainable use of Arequipa's natural resources, improve environmental quality and human health of Arequipa and its communities, and strengthen local and regional economy in sectors important to health, food, energy, water, and sustainable development.

## Collaborative, Peer-Reviewed Publications

Cross-Examining Precipitation Products by Rain Gauge, Remote Sensing, and WRF Simulations over a South American Region across the Pacific Coast and Andes. Chen, M.; Huang, Y.; Li, Z.; Larico, A.J.M.; Xue, M.; Hong, Y.; Hu, X.-M.; Novoa, H.M.; Martin, E.; McPherson, R.; et al. *Atmosphere* 2022, 13, 1666.

Effects of Lower Troposphere Vertical Mixing on Simulated Clouds and Precipitation Over the Amazon During the Wet Season. Hu, X-Ming ; Huang, Y. ; Xue, M.; Martin, E.; Hong, Y.; Chen, M.; Novoa, H. M.; McPherson, R. A.; Perez, A. V.; Morales, I. Y.; Luna, A. F. *Journal of Geophysical Research. Atmospheres* 2023, 128, 12.

Convection-Permitting Simulations of Precipitation over the Peruvian Central Andes: Strong Sensitivity to Planetary Boundary Layer Parameterization. Huang, Y; Xue, M.; Hu, X.M.; Martin, E.; Novoa, H.N.; McPherson, R.A.; Perez, A.; Morales, I.Y. *Convection-ESS Open Archive*. May 25, 2023.

Automated Quantification of Pneumonia Infected Volume in Lung CT Images: A Comparison with Subjective Assessment of Radiologists. Mirniaharikandehei, S.; Abdihamzehkolaei, A.; Choquehuanca, A.; Aedo, M.; Pacheco, W.; Estacio, L.; Cahui, V.; Huallpa, L.; Quiñonez, K.; Calderón, V.; et al. *Bioengineering* 2023, 10, 321.

# LASI Special Events

## Expert Panel Discusses Ongoing Political Protests in Brazil and Peru

In January 2023, protestors attacked government buildings in Brazil with the intent to topple the legitimately-elected government. Angry about the presidential election of Luiz Inácio Lula da Silva, hundreds of supporters of Jair Bolsonaro, the far-right incumbent, broke into and defaced Brazil's congressional building, supreme court and presidential palace. At the same time, Peru faced a deepening political crisis which began in early December 2022 with the impeachment of former President Pedro Castillo. The Peruvian legislature voted on December 7 to remove Castillo from office after the left-wing leader announced plans to dissolve Congress and rule by decree.

On February 9, 2023, the OU Center for the Americas, in collaboration with LASI and the Center for Brazil Studies, hosted a panel discussion for more than 125 attendees that explored the history and complex factors that led to these recent political crises in the two countries.

The panel included Fabio de Sa e Silva, co-director for the Center for Brazil Studies and associate professor in the College of International Studies; Víctor Maque, managing director for LASI and affiliate professor of history; Charlie Kenney, ConocoPhillips Chair in Latin American Studies and associate professor in the Department of Political Science; and Michelle Morais de Sa e Silva, co-director for the Center for Brazil Studies and associate professor in the College of International Studies.

Photos from top to bottom: Fabio Costa Morais de Sa e Silva, Víctor Maque, Charlie Kenney, and Michelle Morais de Sa e Silva.



## LASI Film Series

The LASI Film Series is a collaborative initiative to bring a variety of Latin-America focused films to campus. Interdisciplinary partners across campus helped select films, documentaries and classics highlighting the joys and struggles of communities across Central and South America and the Caribbean. The films also provide a venue for faculty and students to share their experiences with a wider campus audience. All films feature an academic introduction by Victor Maquette and a discussion at the film's conclusion with guest speakers.

### Argentina, 1985

In April, 2023, LASI, with co-hosts the Center for the Americas and the Department of Modern Languages, Literatures and Linguistics, presented a screening of *Argentina, 1985*. A 2022 historical legal drama produced and directed by Santiago Mitre, the film depicts the groundbreaking transitional justice process that took place in Argentina after the military dictatorship. More than 30,000 Argentines were estimated to have disappeared between 1976 and 1983, and some 3,000 people have been charged with crimes as of 2018. Inspired by the true story of Julio Strassera, Luis Moreno Ocampo, and their young legal team, the film provides a dramatic depiction of the justice process, a process that has set precedents for human rights litigation, created awareness around the limits of state power, and influenced peace-building mechanisms after human atrocities. Commentary was provided by a panel of experts that included Dr. Irene Martinez, Argentinian and co-founder of the Kovler Center for the Treatment of the Survivors of Torture; James Cane Carrasco, OU Department of History; and Mathew Kane, OU College of Law.



### Daughter of the Lake (Hija de la Laguna)

LASI, with co-hosts IREES and the Department of Modern Languages, Literatures and Linguistics kicked-off the series with a screening of *Daughter of the Lake*. The film addresses the existing conflicts between indigenous populations and mining companies in the Cajamarca region in Peru. The topic is presented through the perspective of Nélida, an indigenous woman who is a farmer, and now an environmental leader, in a land where mining companies have been working since 1992. Although she loves living in the countryside and taking care of her animals and crops — to which she has a special connection as she feels able to communicate with water spirits — she moved to the city of Cajamarca to go to university. She is currently studying law to defend herself and her community from negative impacts caused by mining activity. Victor Maquette provided opening remarks and facilitated a conversation and Q&A session with Peruvian film director Ernesto Cabellos Damián at the conclusion of the film.





# Meet the IREES Team



**Tim Filley, Ph.D., Executive Director**

*Professor, Department of Geography and Environmental Sustainability and School of Geosciences*

Expertise: biogeochemistry of terrestrial ecosystems, isotope geochemistry, and soil carbon sequestration



**Li Song, Ph.D., Faculty Fellow**

*Professor, School of Aerospace and Mechanical Engineering*

Expertise: Modeling, analysis and control of building energy systems, optimization and control; energy efficiency technology



**Steven Crossley, Ph.D., Associate Director of Low-Carbon Energy & Infrastructure**

*Sam A. Wilson Professor, School of Sustainable Chemical, Biological and Materials Engineering*

Expertise: heterogeneous catalysis and nanomaterials synthesis



**Katerina Tsetsura, Ph.D., Faculty Fellow**

*Professor, Gaylord College of Journalism and Mass Communication*

Expertise: Advertising and public relations, strategic communication, ethics, media transparency, public diplomacy



**Royce Floyd, Ph.D., Faculty Fellow**

*Associate Professor, School of Civil Engineering and Environmental Science*

Expertise: concrete materials and structural engineering with emphasis on increasing the life of concrete structures



**Jackie Vadjunec, Ph.D., Associate Director of Sustainable Societies**

*Professor, Department of Geography and Environmental Sustainability*

Expertise: Human dimensions of global environmental change, cultural and political ecology



**Mikayla Foreman, Operations Manager**

Expertise: Program management, soil carbon management, and agricultural systems modeling



**Kamisha Walker, Administrative Coordinator, Assistant to the Director**

Expertise: Human resources, human relations, community building, and office administration



**Bruce Hoagland, Ph.D., Faculty Fellow**

*Professor, Department of Geography and Environmental Sustainability*

Expertise: Vegetation classification and mapping, analysis of plant species distributions.



**Binbin Weng, Ph.D., Faculty Fellow**

*Assistant Professor, School of Electrical and Computer Engineering*

Expertise: Fundamental and applied nanophotonic research to study the advanced optical structures



**Victor Maqqe, Ph.D., LASI Managing Director**

*Faculty Affiliate, Department of History*

Expertise: Social history of Andean communities, institutional capacity building



**Rouzbeh G. Moghanloo, Ph.D., Faculty Fellow**

*Associate Professor, School of Petroleum and Geological Engineering*

Expertise: Enhanced oil recovery, production, flow assurance and emissions reduction



**Xiangming Xiao, Ph.D., Associate Director of Earth Systems and Global Change**

*Professor, School of Biological Sciences*

Expertise: Ecosystems science and natural resources, ecosystem modeling, ecology and epidemiology of infectious diseases



# IREES Tribal and Indigenous Advisory Board

The IREES Tribal and Indigenous Advisory Board was established to provide insights and recommendations on environmental and energy issues affecting Tribal Nations, their citizens, and indigenous people more broadly. As we work to build the capacity to anticipate, manage, and drive change for a more sustainable, inclusive and prosperous future, we believe guidance from and planning with those with Tribal identity as well as scholarship and practice in the history, challenges, culture and policies of those communities, is essential.



**Tana Fitzpatrick, J.D.**

Associate Vice President, Tribal Relations; Director, Native Nations Center; Member of the Crow Tribe of Montana, and a Sioux, Ponca, and Chickasaw descendent.



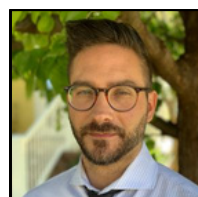
**Jim Collard, Ph.D.**

Director, Planning and Economic Development for the Citizen Potawatomi Nation; Co-founder and Chair of the Tribal-Municipal Dialogue; Professor, Christopher C. Gibbs College of Architecture.



**Victor Maquette, Ph.D.**

Managing Director, Latin America Sustainability Initiative (LASI); Affiliate Faculty, Department of History; Quechua Native from Peru.



**M. Alexander Pearl, J.D.**

Professor of Law; Citizen of the Chickasaw Nation; nationally recognized scholar in the field of Federal Indian Law. Academic scholarship focused on the fields of Federal Indian Law, water rights, Constitutional Law, and statutory interpretation.

# IREES Affiliates Program

## Join our growing community



The Institute for Resilient Environmental and Energy Systems is building a community of researchers across all areas of scholarship and practice to advance knowledge and create solutions to pressing environmental and energy challenges.

Our community of affiliates represents a diversity of disciplines in the social, natural, and physical sciences, education, humanities, business, public health, computer science, and engineering from across OU. To join, use the QR code above or visit: <http://tinyurl.com/yesbcjmc>

### Some benefits of affiliation

- Connect with IREES community of scholars and professionals on a regular basis – to share ideas and form new interdisciplinary teams.
- Access to IREES-funded competitive grants, administrative support for proposal development, strategic intelligence and capacity analysis, intellectual contributions, and assistance with partnership development.
- Increased visibility of your research and creative activities to a variety of audiences across campus, Oklahoma, nationally, and internationally.
- Consideration for Faculty Fellow appointments (Fellows receive an administrative supplement and a budget to support their activities).

### Affiliate responsibilities

- Serve as an IREES ambassador, embodying the Institute's goal to develop resilient, sustainable solutions to critical environmental and energy challenges through convergent research, interdisciplinary education, and transformative partnerships.
- Acknowledge IREES contributions, for example, on the Proposal Information Sheet when initiating a new proposal, on your web page, email signature, and, if appropriate, on journal publications.
- Promote and attend IREES special events, and share relevant opportunities with students and colleagues.

# Future Plans

**RESEARCH:** The interacting impacts of climate change and land use/land cover change (LULCC) — extreme weather events (e.g., droughts, extreme precipitation and flooding, heatwaves), increased climate variability, degrading air quality, changing ecosystems, and increased zoonotic infectious diseases — are among the most pervasive risks to people and planet. The negative impacts to our energy and transportation infrastructure, natural and managed ecosystems, and human health are becoming ever more apparent, as are the impacts to the U.S. economy and economies around the world. IREES will focus on supporting diverse teams to pursue transdisciplinary and convergent research projects that aim to better understand and reduce the risks from climate change and LULCC, innovate to enable low-carbon and bio-inspired economies, and improve the socio-ecological resilience of communities across rural to urban environments. Our efforts will be supported by an advisory committee with representation from industry, community, and academic sectors. We intend to pursue center-level funding opportunities for OU-led research and demonstration projects focused on low-carbon energy and infrastructure, climate-related impacts and adaptation, and environmental change. These efforts will be paired with expanded opportunities for undergraduate and graduate research internships in the above areas.

**PARTNERSHIPS:** Resilient, sustainable solutions to climate-related problems require teams with broad expertise and we will continue to build collaborations with partners in our region, elsewhere in the United States, and around the world. With a focus on flexibility and impact, we will establish and convene an IREES co-creation board to develop new use-inspired research initiatives that are community and Tribal Nation driven. Expanding the LASI impact to include multinational programs throughout Latin America, we will emphasize critical research needs at the intersection of societal stability, natural resource limitations, environmental and climate vulnerability, and hemispheric security. With partners at the U.S. Department of Energy National Labs we will develop our capabilities in low-carbon emissions industrial processes and fuels, and greenhouse gas measurement, capture, and storage, and monitoring technologies. We will also work to support the State of Oklahoma's Greenhouse Gas Reduction Action Plan and OU's Department of Facilities Management in their energy optimization goals.

**CRITICAL INFRASTRUCTURE:** Our infrastructure investments in FY2024 will focus on three key areas that support measurement, monitoring, and analysis of greenhouse gas emissions in the energy industry, quantify the carbon sink/source potential of terrestrial ecosystems, and assess climate-related impacts (e.g. heat island and air quality) on Oklahoma's urban environments. With this in mind, we anticipate 1) beginning full operation of the Stable Isotope Measurement Facility; 2) growing the KAEFS research impact and faculty opportunities by pursuing funding to build new lab and dormitory facilities; and 3) collaborating with the OKC Office of Public Works, the OKC Office of Sustainability, the Association of Central Oklahoma Governments, and the Oklahoma Department of Environmental Quality to deploy the Oklahoma City Urban Airnet atmospheric monitoring network.

**CAREER DEVELOPMENT:** Our staff provides critical support to the research enterprise, and we will provide funding for continuing education as well as one-to-one mentoring and leadership workshop opportunities. We will establish institutional relationships with professional associations and regional universities.



# Environment, Energy, and Sustainability Strategic Research Vertical Working Group

Pillar 5 of OU's Lead On Strategic Plan is titled "Enrich and Positively Impact Oklahoma, the Nation, and the World Through Research and Creative Activity." It defines four strategic areas of research including environment, energy, and sustainability. These strategic research areas, or verticals, represent a way to encapsulate some of the most wicked grand challenges we face as a planet in the 21st century. In fiscal year 2021, a group of faculty from across campus, working with strategy consulting firm Thinkenomics, drafted a framework outlining the foundation for launching IREES.

## **Working Group Leads:**

Petra Klein (AGS)

Jeff Kelly (CAS)

## **Group Members:**

- |                              |                                  |                        |
|------------------------------|----------------------------------|------------------------|
| • David Ebert (DISC)         | • Jonathan McFadden (CAS)        | • Traci Voyles (CAS)   |
| • Chitru Fernando (CoB)      | • Greg McFarquhar (AGS)          | • Janet Ward (OVPRP)   |
| • Lee Fithian (Architecture) | • Runar Nygaard (MCEE)           | • Xiangming Xiao (CAS) |
| • Scott Greene (AGS)         | • Dimitrios Papavassiliou (GCoE) |                        |
| • Laura Harjo (CAS)          | • Jens Redemann (AGS)            |                        |
| • Scott Hodgson (Journalism) | • Carol Silva (CAS)              |                        |
| • Randy Kolar (GCoE)         | • Lynn Soreghan (MCEE)           |                        |
| • Robert Lifset (Honors)     | • Zev Trachtenberg (CAS)         |                        |





INSTITUTE FOR RESILIENT  
ENVIRONMENTAL AND ENERGY SYSTEMS  
*The UNIVERSITY of OKLAHOMA*

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