TICKLE COLLEGE OF ENGINEERING
INSTITUTE FOR A SECURE & SUSTAINABLE ENVIRONMENT

News from ISSE

Spring Magazine 2023

Institute for a Secure & Sustainable Environment

Director's Message

ISSE Director Dr. Mingzhou Jin

This past year has seen a lot of research activity at ISSE. We have seven new sponsored research projects under way, 25 in process, and five that have been completed. These have yielded many published papers and presentations, so ISSE continues to share its results with the world. Also, Environmental Justice has been added to our portfolio of research.

The big story is about the US DOT $10million Center for Freight Transportation for Efficient & Resilient Supply Chain awarded to UTK as the lead institution. Dr. Jin is the PI, and the Center for Transportation Research will manage the program, which is a five-year contract. The story on page 2 gives all the details of this exciting Tier 1 project.

Funded by Federal Aviation Administration, Dr. Joshua Fu will work with UT Institute of Agriculture to improve soil organic carbon estimates and investigate long-term trends in the US. He will use in-situ measurements from previous studies and incorporate satellite imagery and machine learning methods for more complete spatial and temporal coverage for sustainable aviation fuel from biomass feedstock. Dr. Fu's share is about $285k.

Supported by the Appalachian Regional Commission, Dr. Tim Ezzell continues leading the Appalachian Leadership Institute for the third year and training 30 more ALI fellows from the region.

Congratulations to Khalid Alshibli, whose paper was selected for the prestigious ASTM Award. The research for his paper, *Four-Dimensional Dynamic Synchrotron Microcomputed Tomography Imaging of Gas-Water Interface at High Pressure and Low Temperature,* was funded through an ISSE Seed Grant.

Several research and programmatic milestones were reached during this period. ISSE's collaboration with Schneider Electric for research into building environments is moving ahead with additional funding and equipment and systems installed in TCE. East TN Clean Fuels signed off on a new contract year for Clean Cities with US DOE, negotiated with TVA and Blue Bird to buy or lease an electric school bus through ETCF's school district lending program, and received funding from DOE to hire a program coordinator to manage ETCF's Energy & Environmental Justice Program. Dr. Jin's team from the industrial landfill waste management project has been awarded additional $50,000 to develop a model to evaluate selected technologies that will extend the shelf life of food.

Finally, building on our successful First Annual Research Conference held last September, we have set the next one set for September 15, 2023. Put it on your calendar now!

ISSE, CTR to Lead UT's $10 Million University Transportation Center for Supply Chain Resiliancy

The University of Tennessee, Knoxville, will lead a multi-institutional University Transportation Center aimed at improving the mobility of people and goods across the country.

The U.S. Department of Transportation has announced funding of $2 million per year for five years for the **Center for Freight Transportation for Efficient and Resilient Supply Chain (FERSC)** through its University Transportation Centers Program.

UT will partner with Texas A&M University, the University of Illinois Chicago, Oregon State University, North Carolina Agricultural and Technical State University, and California State University, Long Beach.

"I am thrilled to be partnering with other institutions to effect change for this critical sector," said Mingzhou Jin, John D. Tickle Professor in UT's Tickle College of Engineering, who will lead the center. "Together we will develop innovative technologies and solutions that maximize the capacity of existing roadway infrastructure, ensure the just-in-time delivery of goods that support America's retail and manufacturing economy, and by doing so enhance supply chain resiliency."

The new center will be housed in UT's **Center for Transportation Research** and will address the challenges in freight transportation system design, planning, operations, and innovations in national and global supply chains through research, education, workforce development, and technology transfer activities.

"I am delighted that our researchers were instrumental in the award of three new University Transportation Centers," said Kevin Heaslip, director of UT's Center for Transportation Research and Future Mobility Initiative. "Our engagement puts our program in the country's upper echelon of transportation research. The current momentum in our programs will lead to additional growth in the future as we continue to build research capacity and amplify the impact of our research outcomes."

More than 231,000 Tennesseans are employed in the transportation, logistics, and distribution industry at more than 13,800 establishments, including FedEx and Amazon's Operations Center. Additionally, annual freight volume in the U.S. is expected to increase by 50% to almost 29 billion tons by 2050.

"The state of Tennessee plays a critical role in the U.S. freight network, and UT is committed to conducting transformational work in future mobility in support of both new technology advancements and the creation of a skilled workforce for Tennessee and the nation," said UT Vice Chancellor for Research Deb Crawford.

UT will also be a partner institution in two other University Transportation Centers: the **Center for Pedestrian and Bicyclist Safety**, led by the University of New Mexico, and the **University Transportation Center for Regional and Rural Connected Communities**, led by North Carolina A&T State University.


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ISSE Welcomes New Staff

Chien-fei Chen, Research Associate Professor
Director of Energy & Environmental Justice

Dr. Chen is ISSE's new Director of Energy & Environmental Justice and a research associate professor and director of education and diversity at the Center for Ultra-wide-area Resilient Electric Energy Transmission Networks (CURENT) in UTK's Department of Electrical Engineering and Computer Science. She is also an adjunct faculty in the Department of Sociology at UTK.

Ian Simpson, TN Water Resources Research Center
Research Associate III

Dr. Simpson is a water resources engineer with TNWRRC. He researches pollutant loadings in urban watersheds, effectiveness and maintenance of green infrastructure and stormwater control measures, erosion prevention and sediment control, trend analyses, the "urban stream syndrome," and stream restoration. Also, Ian is revising the state manuals and handbooks for stormwater management. Ian earned his PhD from the Ohio State University in 2022 and his bachelor's degrees in Civil & Environmental Engineering and Applied Mathematics from Ohio Northern University in 2018.

Steven Hoaglund, TN Water Resources Research Center
Research Associate II

Steven manages the Appalachian Community Technical Assistance and Training Program, which serves small and rural water and wastewater utilities in East Tennessee. Before joining the water center, Steven worked as a water resources engineer for Tetra Tech in Lexington, Kentucky, and as a research associate for the Kentucky Water Resources Research Institute. Steven is a fourth-year doctoral student at Virginia Tech and hopes to earn his Ph.D. in Civil and Environmental Engineering in 2023.

Jenni Kidd, Drive Electric TN
East Tennessee Clean Fuels Program Coordinator

Jenni is a Project Coordinator at ETCF and currently handles the coalition's projects with Tennessee Tech University. She comes to ETCleanFuels with a wide array of professional experience and is happy to see all her skills coming together in one place. Jenni is excited to be a part of the non-profit world and can't wait to see what comes next!

ISSE Holds First Annual Research Conference

ISSE's First Annual Research Conference was held on September 15, 2022. Following opening remarks by Dr. **Brad Day**, UTK Associate Vice Chancellor for Research, ISSE Researchers presented their latest work in Water Research (Dr. **John Schwartz**), Clean Energy (**Jonathan Overly**), Regional Sustainability (Dr. **Tim Ezzell**), Climate Change (Dr. **Yulong Zhang**), and Sustainable Food (Dr. **Mingzhou Jin**).

Next, state and community leaders in sustainability gave updates on initiatives in each of their areas. Presenters included **Brian Blackmon** (Sustainability in Knoxville), Dr. Mingzhou Jin (UTK Global Energy Ecosystem Initiative), Dr. **Erin Webb,** Senior R&D Engineer and group leader, ORNL (ORNL Environmental Research and Future Directions), **Matthew Taylor** (TDEC Sustainability Programs), Dr. **Rebecca Tolene**, VP Environment-Chief Sustainability Officer, TVA (TVA Sustainability Efforts), and Dr. **Tom Gill** (International Collaboration on Sustainability Research and Engagement).

An important part of the program was the student poster competition. Student researchers submitted 30 poster for judging, and these are the winners:

- First prize: **Clifford Swanson**, Microbiome of the Drinking Water Distribution System
- Second prize: **Kepler Barnhart**, Micromobility Vehicle Second-Life Battery Applications: Market Inventory and End Use Feasibility Analysis
- Third prize: **Rongyun Tang**, Interannual Variability of Global Wildfires

Wrapping up the program, Dr. **Bill Dunne (**left) and Dr. Jin (right) presented Jonathan Overly (center) with the 2022 Outstanding ISSE Staff Award. Jonathan is a widely-recognized leader in efforts toward national clean fuels use.

Alshibli Paper Selected for Prestigious ASTM Award

Dr. Khalid Alshibli (above) has been chosen to receive the 2023 Hogentogler Award from the American Society for Testing and Materials (ASTM) Committee D18 on Soil and Rock. The research for his paper, "Four-Dimensional Dynamic Synchrotron Microcomputed Tomography Imaging of Gas-Water Interface at High Pressure and Low Temperature," was funded through an ISSE Seed Grant. Co-author Dr. Zaher Jarrar completed his PhD in CEE in December 2020.

Degree of saturation directly influences how soils behave, and the constitutive relationships for partially saturated soils is fundamentally different than fully saturated or dry soils. The presence of both air and water in the pore space introduces capillary forces that influence inter-particle interactions. A small change in the degree of saturation alters suction, which influences soil stiffness and shear strength. This NSF-funded project uses three types of silica sand: Uniform Ottawa sand with rounded-to-sub-rounded particles represent a uniform sand with rounded/sub-rounded particles; angular sand represents sands with a wider gradation and angular particles.

Socioeconomic inequalities and drinking water quality: assessing arsenic concentrations in community water systems by novel field deployable biosensors

Drs. Jayne Wu, Courtney Cronley, and Qiang He sampled tap water from 100 Knox-area household; the samples were tested in the field for chlorine and pH levels. Households were surveyed in advance, and survey data were analyzed according to zip code. Zip codes were characterized based on Census Tract data with four groups emerging: 37914 is mixed race and middle income; 37915 is majority black and lower income; 37917 is majority white and middle income; and zip codes 37920 and 37923 are majority white and higher income. This seed grant project resulted in three research proposals, two journal publications, and a team presentation. A portable, stand-alone system was developed to use for the on-site sensor array. The sensing module has a portable readout unit and an array of electrode chips as the disposable test cartridge.

ISSE Assists Campus-wide Global Energy Ecosystems (GE2) Initiative

A far-reaching group of UTK and UTIA departments and research programs have come together to launch a new research initiative called Global Energy Ecosystems (GE2). The goal is to create a global energy ecosystem that improves quality of life and supports just, equitable, and sustainable energy transitions in industry, agriculture, and lived communities through technological innovation and creative solutions. Led by Dr. Mingzhou Jin, ISSE will assist the Office of Research, Innovation, and Economic Development in building UT's global leadership in energy and sustainability research, policy, outreach, and education.

2022 Annual FEWSUS Conference Buenos Aires

FEWSUS 2022 INTERNATIONAL SYMPOSIUM

Circular Bioeconomy Systems for Urban-Rural Co-Prosperity

FEWSUS 2022 International Symposium of Circular Bioeconomy Systems for Urban-Rural Co-prosperity was held November 30 through December 2, 2022, in Buenos Aires, Argentina. The symposium was jointly sponsored by the U.S. National Science Foundation, the University of Tennessee, Knoxville and Oak Ridge National Laboratory and co-organized by Argentina's Ministry of Science, Technology and Innovation; Secretariat of Agriculture, Livestock and Fisheries; the National Institute of Agricultural Technology; and the School of Agriculture, University of Buenos Aires. The symposium aimed to establish a crosscutting network to coordinate the research-private-public sectors for promoting international collaboration in research, education, and applied technology at the nexus of food, energy, and water systems for urban sustainability (FEWSUS).

Research Experience for Undergrads: Green Infrastructure for Sustainable Urban Environments Kicks off Year 2

Led by PI Dr. Jon Hathaway, Year 2 of the NSF-funded Research Experience for Undergrads is gearing up for its second successful Summer, happening May 27—August 6, 2023. *Green Infrastructure for Sustainable Urban Environments* is a 10-week summer program that exposes 10 undergrads to green infrastructure (GI) research. GI is a way to build, restore, and improve urban infrastructure. This research experience lets students perform field, laboratory, or modeling studies to explore how GI can mitigate the effects of urban runoff on surface water quality and hydrology. Students will dive into a professional and social atmosphere that will develop their fundamental research methodologies and critical thinking skills.

Active Research Projects

2023 ACTIVE SPONSORED RESEARCH

PI	*Project Title*	*Sponsor*	*Co-PI*
Khalid Ahmed Alshibli	*3D dynamic evolution of pore water-air interaction within saturated sheared sand*	National Science Foundation	
Timothy Ezzell	*Increasing Economic and Entrepreneurial Opportunities by Promoting Outdoor Recreation Among Underrepresented Visitor Groups*	East Tennessee State University	
Timothy Ezzell	*ASPIRE: Appalachian Students Promoting the Integration of Research in Education*	National Science Foundation	
Timothy Ezzell	*Appalachian Leadership Institute*	Appalachian Regional Commission	K Cahill, C Wilt
Jon Hathaway	*Wetland Restoration with RSCs*	Environmental Protection Agency	J Schwartz
Jon Hathaway	*REU Site: Green Infrastructure for Sustainable Urban Environments*	National Science Foundation	
Jon Hathaway	*Collaborative Research: Reimagining Urban Watershed Management: A Systems Approach to Stormwater Control and Ecological Rehabilitation*	National Science Foundation	A Khojandi, M Blum
Qiang He	*AOP for wastewater treatment from the oil/gas industry*	Aramco	
Mingzhou Jin	*Anyalysis for Regional and Global Land Ecosystem Modeling, completed*	DOE - ORNL - UT-Battelle - Oak Ridge National Laboratory	
Mingzhou Jin	*Smart Manufacturing*	US Dept Energy/UT-Battelle/Oak Ridge National Laboratory	
Mingzhou Jin	*US Food, Loss, and Waste and Its Relationship with Energy consumption and Carbon Emissions*	US Dept Energy/UT-Battelle/Oak Ridge National Laboratory	
Mingzhou Jin	*East Tennessee Clean Fuels Initiative*	East Tennessee Clean Fuels Coalition	
Mingzhou Jin	*INFEWS: U.S.-China: Coupled FEWS Modeling for Sustainability of the Global Crop Supply Chain with a Focus on China - US Interactions*	National Science Foundation	
Mingzhou Jin	*People-Centric Integrated Assessment Model for Regional Sustainability*	National Science Foundation	T Ezzell, et al.
Jonathan Overly	*TDOT I-40 Alternative Fuels Continuation*	US Dept Transportation - UT Center for Transportation Research	Y Zhang
John Schwartz	*Improving the GRSMs understanding of its natural resources and processes and thereby enhancing protection of the Park's resources*	US Dept Interior National Park Service - Great Smoky Mountains NP	
John Schwartz	*FY2021 and FY2022 Water Resources Program Year 1*	US Dept Interior - US Geological Survey	J Hathaway, Y Wang, T Gangaware
John Schwartz	*FY2022 and FY2023 Water Resources Program Year 2*	US Dept Interior - US Geological Survey	T Gangaware
John Schwartz	*Increasing water treatment resiliency-University of Alabama*	US Dept Interior - US Geological Survey	T Gangaware
John Schwartz	*TN Stream Quantification Tool Training*	TN Dept Environment and Conservation	
John Schwartz	*Urban Waters Report Card*	Metro Gov Nashville	T Gangaware
John Schwartz	*Urban Waters Report Card*	City of Memphis	T Gangaware
John Schwartz	*Urban Waters Report Card*	Hamilton County Government	T Gangaware
John Schwartz	*Appalachian Community Technical Assistance and Training Program*	West Virginia University	
Sheila Webster	*Worker Training at DOE facilities*	National Partnership for Environmental Technology Education	
Nick Zhou	*Utilizing coal-derived solid carbon materials towards next-generation smart and multifunction pavements*	US Dept Energy - National Energy Technology Lab	B Huang, W Hu

NEWLY-AWARDED SPONSORED RESEARCH			
PI	*Project Title*	*Sponsor*	*Co-PI*
Mingzhou Jin	*Center for Freight Transportation for Efficient and Resilient Supply Chain (FERSC)*	US Dept Transportation	Lee Han, Kevin Heaslip
Mingzhou Jin	*ETISE: East Tennessee Inititiative of Smart Manufacturing for Energy Efficiency*	US Dept Energy Office of Energy Efficiency	
Chien-fei Chen	*Advancing Human-Centered Sociotechnical Research for Enabling Independent Mobility in People with Physical Disabilities*	University of Michigan	
Chien-fei Chen	*Community-centered Decision-making Framework for Microgrid Deployment ot Enhance Energy Justice and Power System Resilience*	Iowa State University	
Chien-fei Chen	*A Community Co-design-based Weatherization and Micro-grid Plan for Equitable Energy Security and Environmental Health*	Wellcome Foundation	
Joshua Fu	*Estimating Soil Organic Carbon Changes from SAF Feedstock Production in the US with Integrative Satellite Data and Machine Learning*	US Dept Transportation Federal Aviation Administration	
John Schwartz	*Urban Waters Report Card*	City of Chattanooga	Timothy Gangaware

Milestones

Several active research projects and initiatives have made significant achievements toward meeting goals and milestones. The following represent a few such accomplishments:

Testing the pilot system for Building Environment Research, Mingzhou Jin, PI.
Collaboration with Schneider Electric
The collaboration between ISSE and Schneider Electric has moved forward after signing a non-disclosure agreement, and Schneider has promised additional funding of $50,000. Schneider will soon deliver its devices and systems to be installed in Tickle College of Engineering. Drs. Qiang He and Shuai Li will use the increased funds and the system installed by Schneider for research and proposal development that will evolve into a Center for the Built Environment at UT.

New Contract Year for Clean Cities, Jonathan Overly, PI.
US Department of Energy
East TN Clean Fuels Coalition has met all DOE requirements for the annual Clean Cities contract renewal:

- Coalition Strategic Plan
- Coalition Building & Stakeholder Engagement
- Market Development Events, Workshops, & Meetings
- Corridor & Community AFV Infrastructure Planning & Development
- Technical Assistance & Fleet Coaching; and Technical Training & Education

Electric School Bus Procurement and Tennessee Tour Showcase Program, Jonathan Overly, PI.
Tennessee Valley Authority
Mr. Overly successfully negotiated with TVA and Blue Bird bus supplier to purchase or lease one electric school bus through a developing school district lending plan.

DOE Clean Cities Energy & Environmental Justice Program, Jonathan Overly, PI.
US Department of Energy
This DOE funding allows ETCF to hire a program coordinator to manage ETCF's Energy & Environmental Justice Program.

Industrial Landfill Waste Management, Mingzhou Jin, PI.
US Department of Energy-UT Battelle-ORNL
The team has completed a draft paper about energy consumption and improvements along the US food supply chain. The project has been awarded an additional funding of $50,000. The next step is to develop a model to evaluate selected technologies that will extend the shelf life of food.

Continuing Research

Each ISSE program has conducted significant research this past year: water resources through four US Geological Survey projects; methane hydrates and global soil moisture datasets; establishing a US-China transdisciplinary research coordination network to identify challenges at the nexus of food-energy-water systems; trends in Appalachian tourism and diversity; and local research for equitable energy security and environmental health. ISSE research projects have engaged more than 50 UT faculty members, post-doctoral students, and many graduate and undergraduate students. ISSE's six main areas of research are

- Clean Energy & Energy Efficiency
- Climate Change
- Environmental Justice
- Regional Sustainability
- Sustainable Food Systems
- Water Research

The following are highlights from a project or initiative in each topic area.

Clean Energy & Energy Efficiency

Testing the Pilot System for Building Environment Research
Mingzhou Jin, PI, Collaboration with Schneider Electric
In 2022, ISSE received a gift of $58,000 from Schneider Electric to launch a Building Environment Initiative. Recently, Schneider strengthened its support by signing a non-disclosure agreement with ISSE and increasing its funding with an additional $50,000. Schneider will deliver its devices and systems to be installed in Tickle College of Engineering. Drs. Qiang He and Shuai Li will use the increased funds and the system installed by Schneider for research and proposal development that will evolve into a Center for the Built Environment at UT. The team, which won the 2021 Provost Award for Success in Multidisciplinary Research, will employ Schneider's digital building technologies to develop innovative tools and solutions for energy savings, human health, and productivity improvement.

ISSE will build a live lab to conduct research on smart buildings for energy saving and human health through data collection and integration, analytics, adaptive controls, and the engagement of people. Buildings account for about 40% of all primary energy use and associated greenhouse gas emissions in the US. This new initiative aims to reduce energy consumption in buildings to meet national energy and environmental challenges. Because people spend about 90% of their time indoors, interior environments have a significant impact on our health and productivity.

Climate Change

Climate change is one of the most critical challenges faced by human being and our planet. Researchers at ISSE, closely working with the Climate Change Science Institute at Oak Ridge National Lab, is advancing our understanding of climate change and its impacts on human and natural systems. We use Earth system modeling, integrated ground and remote sensing observations, and advanced data analytical tools to study climate change and its impacts on water availability, soil moisture, wildfires, and vegetation.

Examining Soil Moisture as a Climate Change Issue
Mingzhou Jin, PI

Despite growing evidence of human influence on terrestrial aridity, there is considerable uncertainty on the spatial, vertical, and seasonal patterns of recent and future changes in soil moisture-based terrestrial aridity and associated environmental drivers. The team formed by researchers at ISSE and Oak Ridge National Lab calculated a Standardized Soil Moisture Index (SSI) for two soil layers (0–10 and 0–100 cm) from newly merged soil moisture data sets, conducted pattern-based detection and attribution analysis to quantify the impacts of natural and anthropogenic forcings on the monthly trends in the zonally averaged SSI, and developed an emergent constraint–based approach to use the historical signal-to-noise ratios of the detection and attribution to constrain future evolution in the zonally averaged SSI.

The team found that widespread drying occurred in the midlatitudes of both hemispheres from 1971 to 2016, and wetting occurred in the northern subtropics and in the spring between 45°N and 65°N. Human forcings, mainly greenhouse gas emissions, exerted significant influences on the surface SSI from August to November and on the root-zone SSI from September to April; anthropogenic aerosol emissions might have played a role in some months and soil layers. Observation-constrained future SSI changes under the Shared Socioeconomic Pathway 5–8.5 scenario showed the continued presence of human impacts and more rapid drying of the surface soil than the root-zone soil.

The findings highlight the predominant human contribution to terrestrial aridification and reveal the spatiotemporal heterogeneity therein, providing a basis for drought and flood risk reduction strategies and activities. The paper summarizing these findings has been accepted by Nature Communications. In addition, the team developed seven global, gap-free, long-term (1970–2016), multilayer (0–10, 10–30, 30–50, and 50–100 cm) SM products at monthly 0.5 resolution and published at Earth System Science Data. The merged products outperformed their source datasets when evaluated with in situ observations regarding bias and errors.

Environmental Justice

A Community Co-design-based Weatherization and Micro-grid Plan for Equitable Energy Security and Environmental Health , Chien-fei Chen, PI, Wellcome Foundation
The goal of this project is to design intervention and solutions to study the impacts of climate on undeserved communities' physical and mental health at both micro-and macro-levels. It addresses a critical need to conduct local research on climate health and a sustainable communication solution. Specific objectives include: GIS tool, and mapping, machine learning, micro-grid acceptance study and community engagement.

Regional Sustainability

Urban Waters Report Card, PI John Schwartz
TNWRRC is working with a group with members from Nashville Metro, cities of Chattanooga and Memphis, counties of Shelby, Hamilton, and Knox, the Tennessee Stormwater Association, and Tennessee Department of Environment and Conservation to develop an Urban Waters Report Card (UWRC) to "grade" the quality of streams in communities that maintain a stormwater management program. Jason Brown and Ian Simpson, Research Associates at the TNWRRC are aiding in the production of the UWRC. Each of the municipalities listed above has contributed funding to develop the Report Card.

UWRC should provide Municipal Separate Storm Sewer Systems (MS4) a means to track stream improvements from their stormwater management and stream rehabilitation efforts. Even with considerable efforts by the MS4s, many streams will continue to fail to meet their designated uses and therefore remain on the impaired waters list. An A-to-F grading scale for the UWRC will create an assessment scheme that demonstrates the incremental improvement of a stream's condition. Such a scheme is more informative to local stakeholders, including the MS4 professional and administrative staffs, political leaders, and the public. The planned framework of the UWRC is simple and intuitive: Number of categories are to be graded including water quality, watershed hydrology and connectivity, and stream corridor characteristics such as habitat, channel stability, and riparian vegetation. A composite grade will be reported for each stream assessed and made available on a web site that is currently under development. A beta-version of the UWRC will be completed Spring 2023.

Sustainable Food Systems

Responding to the second UN Sustainable Development goal of ending hunger and achieving food security, ISSE studies food sustainability in the United States and the world, using analytic models and pursuing systematic solutions. We assess the sustainability and resiliency of the global food systems by carefully considering socioeconomic, policy, and climate scenarios.

Food and Energy Nexus, PI Mingzhou Jin
Supported by the Department of Energy's Advanced Manufacturing Office, researchers from ISSE and ORNL are studying the energy consumption and greenhouse gas (GHG) emissions along the U.S. food supply chain. Identifying the high impact areas is the first step to transforming the U.S. food sector to net-zero emissions. This work yields a database of energy consumption and GHG emissions from the U.S. food system at national and state level by FSC stage, fuel type, and food commodity. We estimate that the U.S. food system consumed a total 4,787 TBTU of site energy, 7,258 TBTU of primary energy, and it generated 984.1 MMT of GHG emissions in 2016. Among all the FSC stages, on-farm production is the largest energy consumer (35% primary) and, by far, the largest source of GHG emissions (71%). Raising animals (for dairy, meat, poultry, eggs, or seafood products) requires a large portion of the on-farm energy consumption and creates the largest portion GHG emissions, making this a key target of any efforts of energy use and GHG reduction.

Optimizing the U.S. food distribution system can directly reduce the distribution stage energy consumption and GHG emissions and increase products' shelf-life, reducing food loss and waste generation and the energy consumption and GHG emissions to produce them. Reducing food loss and waste generation is one of the best options for reducing the impact of the FSC, as it also reduces the amount of food that is necessary to grow, and thus impacts the overall FSC. With the developed database, future work by the authors or others can help create detailed analyses to understand the benefits and impacts of each proposed strategy. The database can be used to identify stage- and regional-specific strategies and goals as well as other, more substantial ways to change the environmental impact of the food system.

Water Research

Sourcing Runoff and Chemical Origins in Urban Stormwater Runoff: An Application in Knoxville, Tennessee,
PI Jon Hathaway

Hydrologic regimes in urban streams are altered by increased runoff from impervious surfaces. Runoff also delivers pollutants that have collected on impervious surfaces during dry periods antecedent to storm events. Determining the source of stormwater runoff (and thus the associated source of pollutants) is a critical need in urban hydrology to optimize siting of stormwater controls and improve water quality modeling. This project uses stable isotope analysis of nitrogen (∂15N) and oxygen (∂18O) for dissolved nitrate, and sulfur (∂34S) and oxygen for sulfate as environmental tracers for stormwater source partitioning in the unique urban watershed of Baker Creek in the City of Knoxville, TN.

Three monitoring sites were established: (1) at the forested headwaters (BCP), (2) at a node entirely fed by urban runoff (MJP), and (3) at a node downstream of where points 1 and 2 combine (LEN). Stream and runoff samples were taken during different seasons and hydrological conditions (e.g., rain, baseflow). Preliminary isotope results suggest that atmospheric deposition and soil processes are the main contributors of nitrate/nitrite into the Baker Creek. In contrast, sulfate is mainly sourced from surface water and groundwater interaction with the bedrock (e.g., evaporite dissolution, sulfide weathering). During the study period, contributions of nitrate/nitrite and sulfate from the local sewer systems were minor, if any. Generally, the ∂15N, ∂18O, and ∂34S appear to be useful tracers in studying source partitioning in urban runoff and stream water, which are sensitive to changes in hydrological conditions.

Seed Grants

ISSE makes annual funding available for multi-disciplinary, multi-investigator research and support. Each year, ISSE awards three or four seed grants to support research projects that are related to environmental sustainability. The aim is to support project teams as they develop interdisciplinary collaboration and build the capability to secure external funding. ISSE expects the funded teams to submit at least one external grant proposal and one article to a peer-reviewed publication acknowledging ISSE's support. Among the topics of interest are

- Modeling sustainability and resilience for regional systems under climate changes and other social and environmental stressors;
- Systems or engineering solutions to reduce nutrient and pollution (e.g., microplastics) in water;
- Technologies and analyses for carbon sequestration; and
- Solutions or modeling to enhance environmental health.

For FY2023, a panel of independent reviewers scored all submissions and selected the following projects.

ACTIVE SEED GRANTS

PI	*Project Title*	*Co-PI*	*Duration*
Jiangang Chen	*Assessing the levels of forever chemicals (PFAS) in surface water in Tennessee aquatic ecosystems*	Jie Wu, Qiang He	7/1/2022 - 6/30/2023
Alison Buchan	*Identification of novel pathways for bacterial degradation of polycyclic aromatic hydrocarbons*	Qiang He	7/1/2022 - 6/30/2023
Baoshan Huang	*Utilization of Waste Plastics*	Qiang He, Brian Long, Pawel Polaczyk	7/1/2022 - 6/30/2023
Chris Cherry	*Micromobility Vehicle Second-Life Battery Applications: Market Inventory and End Use Feasibility Analysis*	Daniel Costinett	7/1/2022 - 6/30/2023

COMPLETED SEED GRANTS

PI	*Project Title*	*Co-PI*	*Duration*
Khalid Alshibli Ahmed	*Geochemical Interaction between CO2 and Caprock for Safe Carbon Sequestration*	Nicholas Dygert	1/1/2021-12/31/2022
Qiang He	*Toward Precision Environmental Health Risk Management*	Cronley & Li	1/1/2021-12/31/2022
Kelsey Ellis	*Beat the Heat: Builiding adaptive capacity of vulverable populations in Knox County to combined stressors from climate change and urban heat.*	First & Kintziger	7/1/2021 - 12/31/2022
Frank Loeffler	*Microbial transformation and degradation of sulfonated per- and polyfluoroalkyl substances.*	Shawn Campagna	7/1/2021 - 12/31/2022
Jie Wu	*Socioeconomic inequalities and drinking water quality: assessin arsenic concentrations in community water systems by novel field deployable biosensors.*	Cronley & He	7/1/2021 - 12/31/2022

right: An e-bike user removes a spent battery that can be used for a second-life application.

Seed Grant Spotlight

Micromobility Vehicle Second-Life Battery Applications: Market Inventory and End Use Feasibility Analysis

Chris Cherry, Kepler Barnhart

Project at a Glance

- Shared e-bikes and scooters have short life spans of roughly five years, but their batteries could be used for non-propulsion energy storage after their first lives.
- The supply of used batteries is growing rapidly due to the success of shared electrified micromobility in cities across the US.
- Demand for residential and commercial energy storage is growing, especially as a means to store power generated from wind and solar.
- Battery cell construction in e-bikes and scooters is standardized in the micromobility industry and some EVs, making each cell versatile for second life applications.

Why is this important?

The Bipartisan Infrastructure Law (BIL) signed in November of 2021 focuses its funding toward our battery supply chain (including second-life applications) in part to reduce the growing need to extract and mine critical minerals. This project is investigating the feasibility of extending shared e-bike and scooter batteries for second life applications by extending battery life, reducing residential and commercial grid reliance, and helping determine the economic feasibility of novel, second-life battery applications arising from recent e-bike and scooter battery improvements

Best Approach

To map out an approach to alleviate this supply chain challenge, the project team will inventory the batteries used in the shared e-bike/scooter industry to determine the key characteristics, quantity, and typical capacity of second-life battery cells. They will investigate safe and efficient reverse logistics strategies, test the churn rate of used battery cells, and research and demonstrate second-life battery applications to prove utility and cost efficiency of small scale residential and commercial energy storage.

Energy Storage Applications

Some second-life battery applications could be to store solar power for residential use. Such stationary energy storage could support microgrid energy systems, especially during peak pricing hours. These batteries could supply low energy demand applications such as utility lights and parking meters. In Taiwan, Gogoro, the world's largest battery-swapping network, is using retired e-scooter batteries to power parking meters.

Next Steps

The next steps will be to leverage partnerships with Lime and Bird, (world's largest shared electric vehicle company), for access to data and batteries, work with Call2Recycle (a battery recycling program) as a supply source for batteries from owned markets, report feasibility and market potential for second-life projects, and seek additional funding and opportunities through a DOE Small Business Innovation Research Phase 1 Grant and commercial partners.

EDUCATION

Training & Education

ISSE focuses on innovative educational and environmental projects that employ the latest technologies (or explore the use of such technologies) to resolve problems and explore complex issues. Most projects combine the resources of private and governmental sectors with the expertise of University staff, faculty, and students through team agreements.

Appalachian Community Technical Assistance and Training (ACTAT) Program, John Schwartz

The ACTAT Program is funded by the USDA Water and Environmental Programs and awarded to water centers at West Virginia University, University of Kentucky. and the University of Tennessee, Knoxville.

The ACTAT Program helps small rural communities throughout Central Appalachian subregions improve drinking water and wastewater infrastructure operations and become eligible for financial resources to improve their vulnerable water infrastructure, a first step towards community economic growth. ACTAT supports the USDA's Rural Utilities Services objective to help improve quality of life and increase economic opportunities for rural people. The ACTAT Program is focused on economically distressed or at-risk counties, where median household incomes are less than 80% of the respective state's median household income.

Lessons learned from our program will be shared with other similar areas across Appalachia online through a Regional Symposium. This past year, Steven Hoagland gave a training course with communities near Greenville and met with the communities of Norris, Cumberland Gap, and Luttrell.

About the Program

The University of Tennessee, Knoxville has partnered with West Virginia University and the University of Kentucky to help small Appalachian communities improve the level of service provided by their

water and wastewater utilities. Improvements in the operation and maintenance of these systems will not only improve the quality of life for the community, they are often the first step toward future development and economic growth.

We use multiple methods of assistance to support utilities including regional- and utility-specific workshops, tailored educational materials, and hands-on technical assistance. After initial conversations with utility staff, board members, or local decision-makers, ACTAT staff match appropriate experts in engineering, business and management, law, public health, communications, and stakeholder engagement to personalize training and technical assistance. All workshops and technical assistance are offered free of charge.

Workshops Offered

ACTAT offers free technical assistance and training to small water and wastewater utilities in east Tennessee. Continuing education units (CEUs) are available for each workshop. ACTAT staff are prepared to conduct these workshops:

- Hydraulic Modeling of Water Distribution Systems
- Asset Management and Capital Improvement Plans
- Sustainable Management of Small Utilities

The staff can also facilitate workshops on other topics through our partnership with the Kentucky Water Resources Research Institute (KWRRI) at the University of Kentucky and the National Environmental Services Center (NESC) at West Virginia University. Additional workshop topics are:

- AWWA M36 Water Auditing, KWRRI, University of Kentucky
- Basic Mathematic Skills for Operators, KWRRI, University of Kentucky
- Emerging Contaminants of Concern, KWRRI, University of Kentucky
- Overview of the Safe Drinking Water Act, NESC, West Virginia University
- Overview of the Clean Water Act, NESC, West Virginia University
- Stakeholder Engagement, NESC, West Virginia University

Technical Assistance

After an initial meeting with utility staff, board members, or local decision-makers, ACTAT staff are able to provide free technical assistance. Depending on the specific need of the utility or community, we may offer assistance ourselves, request assistance from other university staff with the appropriate area of expertise, or help solicit external assistance.

OUTREACH

Outreach & Partnerships

ISSE & CURENT Host Energy and Environmental Justice Workshop

The Energy and Environmental Justice workshop hosted by Dr. Chien-fei Chen, Director of Energy and Environmental Justice at ISSE, featured speakers from humanities, social sciences, engineering, policy, and energy justice.

Dr. Amy Elias, Director of UTK's Humanities Center, talked about research in energy histories, arts, and aesthetic studies. She discussed ways to integrate art and architecture in community centers via projects that are energy-centered.

Dr. Jon Shefner, Professor of Sociology at UTK, discussed integrating social sciences into energy and environmental justice. Knoxville is growing in green jobs, with work in environmental remediation and a revival in blue collar jobs. Dr. Shefner emphasized the importance of community and research collaboration and discussed UT's support of research into adopting alternative fuel vehicles in disadvantaged communities.

Dr. Asad Khattak, Beaman Professor in Civil & Environmental Engineering, presented application of statistical and explainable AI technologies. Frameworks that guide this research includes Justice40 data, beh. survey, and alternative fuel studies. Measurements in disadvantaged communities show that adding public charging stations benefits these communities.

Supriya Chinthavali from Oak Ridge National Lab explained models such as EAGLE-I, NAERM, and ODIN. Ninety percent of the energy industry is private, so we must develop a systemic wat to collect this information from utilities. EAGLE-I (Environment for Analysis of Geo-Located Energy Information) started collecting public data to reduce this barrier. ODIN (Outage Data Initiative Nationwide) was created to better distribute and share energy data.

Energy Justice- through the lens of resilience, presented by Dr. Bandana Kar from the U.S. Department of Energy and AAAS STP Fellow of Building Decarbonization, discussed the importance of creating and using models that promote energy resiliency. This includes risk assessment, impact assessment, and risk communication. GIFFT, wide area outage analysis using satellite imagery, STATIONS, and rePOWERED are all models that help address this.

Maria Gillens, TVA Director of Energy and Environmental Policy, discussed TVA's Environment and Energy Policy initiatives. TVA's current goals are to set a climate and sustainability vision, inform planning and operations, manage TVA's environmental footprint, and support people to thrive.

Appalachian Teaching Project 2021-2022: Charge-Up Appalachia: Strategies to improve Electric Vehicles along Tennessee's ADHS Corridors

Jean Mercer, Associate Vice Chancellor for Research
Tim Ezzell, Assistant Research Professor, Department of Political Science and ISSE

This Year's UT ATP class examined Electric Vehicle (EV) infrastructure along Tennessee's Appalachian Development Highway System (ADHS) corridors and developed recommendations for improving EV access along these routes. The class created and distributed an EV driver's survey to help determine charging habits and preferences. They conducted an EV perception survey, distributed to stakeholders across East Tennessee, to help understand local EV perceptions and to identify potential barriers to adoption. The class also

conducted field research, with student teams traveling in EVs the length of three ADHS corridors in Tennessee. During the research, students identified potential charging sites, noted local barriers, and met with local stakeholders, including local officials (i.e., the mayors of Dunlap and Cumberland Gap), business owners, and other EV drivers. Using these findings, students developed recommendations for future charging sites and guidelines for future charger installations.

Students presented these findings at a forum at UT's Baker Center for Public Policy. The forum was attended by over fifty participants, including representatives from TVA and TDEC. The project, which aligned closely with existing efforts by both TDEC and TVA, achieved these goals:

- The class developed recommendations to help TVA, TDEC, and other stakeholders implement a statewide EV infrastructure plan and helped introduce underserved areas into that planning process.
- The class developed recommendations to encourage ARC to include EV infrastructure in future ADHS project planning.
- The class improved awareness of EVs in Tennessee's Appalachian communities.
- The students gained a better understanding of the challenges and opportunities that exist in Rural Appalachian communities.
- The class used surplus funds to purchase a level 2 smart EV charger for the town of Cumberland Gap. The town installed the charger this summer. The charger and the data it generates will be incorporated into UT's upcoming 2023 ATP project and it will continue to serve the community afterwards.

East TN Clean Fuels/Drive Electric TN,
Jonathan Overly

East Tennessee Clean Fuels is the project lead on a 2020 DOE-funded project that works with 14 states to build their statewide 'Drive Electric' programs. The project's priority areas include developing branded websites, hosting outreach events, and creating social media campaigns; educating consumers and developing state chapters; planning electric vehicle (EV) charging infrastructure; reaching out to local and state government officials; engaging car dealers; and creating fleet partnerships for EV adoption.

Before project completion, Drive Electric Tennessee (DET) will develop long-term funding approaches and expand the program to include additional states beyond the original 14. During summer 2021, the project added four states (Indiana, Kentucky, Connecticut, and New York) and discussions are currently underway with another dozen Clean Cities Coalitions. Additional states will be able to use all materials developed from the project to help establish their initiatives.

A cooperative partnership with Tennessee Technological University expanded to include a second, multi-state project that will bring a medium-duty electric truck ("eTruck") to fleets across Tennessee, where they will be able to borrow the truck for up to two months to vet its use in fleet operations. Data from fleet use will not only help the fleets understand their potential applicability to electric truck use but also feed an information system to better understand various fleets' needs and desires with EVs.

DET efforts expanded to include further chapter development and to hold more Ride & Drive events in various areas across Tennessee. The "Appalachian Highlands Chapter" of DET, which covers the northeastern part of the state, ramped up in April 2021. Two events were held including the first-ever Ride & Drive in Bristol, Tennessee that brought together about 25 local EV owners and reached nearly 100 citizens during the day with information about how EVs work and where you charge them. Attendees were able to drive EVs such as the Ford Mustang Mach-E, the Tesla Model 3, and the Nissan Leaf.

TNWRRC Takes Annual GSMNP Stream Sampling Trek,

John Schwartz and Ian Simpson

As part of the research in the Great Smoky Mountains National Park on the effects of acid deposition and stream water quality, twice a year a major sampling effort is conducted collecting water samples on Hazel Creek, a remote valley in the Smoky Mountains. The day consists of an 11-mile hike starting at Clingman's Dome, hiking down the Appalachian Trail to the Welsh Ridge Trail, then onto the Hazel Creek trail and dropping down in to the valley, which then follows the creek. This is the path to Hazel Creek, the stream Drs. John Schwartz and Ian Simpson of the Tennessee Water Resources Research Center sampled this spring. Hazel Creek is beautiful cascading down the valley. Many stream crossings are required along this journey. The Park Service picked up Schwartz and Simpson on an all-terrain vehicle about four miles from Lake Fontana, where they then took a boat ride to the marina and were driven back to Clingman's dome. Another successful sampling trip!

above: Dr. Ian Simpson takes water samples from Hazel Creek in the Great Smoky Mountains National Park

right: DriveElectricTN and East Tennessee Clean Fuels staff talk with the public at a recent Ride & Drive event.

PUBLICATIONS

Publications & Presentations

Publications

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Presentations

Hazen, T. C. Invited Webinar. Exxon Valdez vs. Deepwater Horizon and Considerations for Peru Repsol Spill. Online. Lima, Peru. January 27, 2022. Pontificia Universidad Católica del Perú.

Hazen, T. C. Invited Webinar. Repsol Oil Spill in Peru. Online. Lima, Peru. February 8, 2022. National Service of Protected Areas (SERNANP) from the Ministry of Environment (MINAM).

Hunter, E., K. N. Ellis, J. First, and K. Kintziger: Beat the heat: Building adaptive capacity of vulnerable populations in Knox County to combined stressors from climate change and urban heat. Institute for a Secure and Sustainable Environment Research Conference. 15 September 2022. Poster.

J. Wu, Socioeconomic inequalities and drinking water quality: Assessing arsenic concentrations in community water systems by novel field deployable biosensors, Social Inequality of Energy, Environment and Technology Workshop, University of Tennessee, August 6, 2022

Jin, Mingzhou, Automated Warehouse Design Considering 2D and 3D Automated Storage and Retrieval Systems, IISE Annual Conference, May 21-24, 2022, Seattle, WA.

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Miller, J. I., S. M. Techtmann, J. Fortney, N. Mahmoudi, D. C. Joyner, J. Liu, S. Olesen, E. Alm, A, Fernandez, P. Gardinali, N. GaraJayeva, F. S. Askerov and T. C. Hazen. Contributed. Potential for rapid microbial biodegradation of petroleum hydrocarbons in hypoxic marine environments. San Antonio, TX. October 7-9, 2019. International Petroleum Environmental Conference Annual Meeting.

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Overly, J. and Danniel Siksay, East Tennessee Clean Fuels redesignation webinar, September 19, 2022.

Palino GM, Thompson J, Schwartz J, Hathaway J. 2022. Presentation. Hydraulic modeling of regenerative stormwater conveyances. UCOWR/NIWR Annual Water Resources Conference. Greenville, SC.

Rexhausen, V., Hathaway, J.M., and Anna Szynkiewicz. (January 2022) "Using isotopic source partitioning of urban runoff to verify effective impervious area model in a partially forested, partially developed urban watershed" Urban Drainage Modeling Annual Meeting. (Virtual Oral Presentation.

Rezaei, S., Haque, A., Khojandi, A., Brakewood, C., Jin, M., & Cherry, C. (2021). Improvement of Park-and-Ride Facilities and Services in Metropolitan Areas of Tennessee. Poster session presented at the meeting of Tennessee Department of Transportation Innovation Fair and Research Symposium.

Robertson, Savannah, Tennessee Smart Mobility Conference, Nashville, TN, August 4–5, 2022.

Social Inequality of Energy, Environment and Technology Workshop, Aug. 6, 2022, UT. "Socioeconomic inequalities and drinking water quality: Assessing arsenic concentrations in community water systems by novel field deployable biosensors," team presentation

V.Rexhausen, J.M Hathaway, A. Szynkiewicz. (January 2022) "Using isotopic source partitioning of urban runoff to verify effective impervious area model in a partially forested, partially developed urban watershed" Urban Drainage Modeling Annual Meeting. (Virtual Oral Presentation)

Xu Zheng and Mingzhou Jin, Modeling and Analysis of Sustainable Soybean Supply between China and the U.S., IISE Annual Conference, May 21-24, 2022, Seattle, WA.

Recogniton

Dr. **Jon Hathaway**, Associate Professor (CEE), is a senior member of an award-winning research team led by colleagues in the Department of Industrial Systems Engineering, including Dr. Anahita Khojandi and Dr. Xueping Li. The team was honored with the Best Paper Award by Omega journal for their paper "Optimizing green infrastructure placement under precipitation uncertainty." Their research addresses the impacts of increased urbanization, infrastructure degradation, and climate change on stormwater systems across the nation. The team developed modeling to determine optimal placement of green infrastructure practices across a set of locations in a watershed and minimize the total expected runoff under medium-term precipitations uncertainties.

Jonathan Overly, ISSE Outstanding Staff Award 2022. This is the first time this award was given; it will be awarded annually.

East TN Clean Fuels and Madelyn Collins, ETCF Project Coordinator, were chosen by the U.S. Department of Energy to participate in an Energy and Environmental Justice (EEJ) educational program. This is the second part of a three-part program focused on EEJ work for Clean Cities Coalitions. Collins has been able to travel to Chicago, Illinois twice to participate in in-person workshops as well as several other virtual workshops focused on teaching Coalitions how to engage with EEJ communities and incorporate EEJ into all future programs and projects.

East TN Clean Fuels was chosen by the TN Department of Environment and Conservation and the TN Department of Transportation to host this year's TN Sustainable Transportation Forum & Expo (STFE) in Knoxville, TN in November 2022. The Drive Electric Tennessee initiative will also host a one-day conference before STFE in November 2022 called the DriveElectricTN Momentum Summit.

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