ECOLOGICAL SCIENCES & ENGINEERING
INTERDISCIPLINARY GRADUATE PROGRAM

THESIS DEFENSE

April 3, 2025, 9:00 AM located in POTR 212 | Zoom

Addressing Uncertainty in Economic and Environmental Assessments of Emerging Energy Technologies

The transition to clean energy is essential for achieving global sustainability goals, but economic and environmental uncertainties present significant challenges to its large-scale adoption. This research examines how uncertainty impacts the feasibility and sustainability of emerging energy technologies, including bio-jet fuels, hybrid microgrids, and rare earth permanent magnets. It addresses the unpredictability of market fluctuations, policy shifts, and technological performance, which often hinder reliable investment decisions and slow commercial deployment.

By identifying and quantifying key sources of uncertainty, this research enhances the accuracy of techno-economic analyses (TEAs) and life cycle assessments (LCAs), offering more robust frameworks for evaluating emerging energy projects. It also focuses on bridging the gap between laboratory-scale innovations and commercial-scale implementation by refining TEAs and LCAs to better reflect real-world conditions. The study reveals how factors such as fluctuating feedstock prices, inconsistent technology efficiency, and supply chain disruptions can significantly alter cost structures and sustainability outcomes. It highlights the importance of designing adaptable and resilient energy systems capable of withstanding variable market and policy conditions while maintaining economic competitiveness.

In addition to addressing financial risks, this dissertation explores the environmental trade-offs associated with scaling emerging energy technologies. By analyzing the lifecycle impacts, it identifies potential emissions reductions and resource efficiencies, while also highlighting unintended environmental consequences. The findings emphasize the need for integrated assessment frameworks that balance economic viability with ecological sustainability, ensuring that large-scale deployment of these technologies contributes to net-positive environmental outcomes.

Overall, this research provides actionable insights for policymakers, industry stakeholders, and investors by offering strategies to mitigate risks and improve decision-making. It underscores the importance of adaptive policies and resilient supply chains to support the widespread adoption of emerging energy solutions. By promoting more reliable assessments, this research supports the development of cost-effective, scalable energy technologies, accelerating their path from innovation to real-world deployment.

Neha Shakelly

Ph.D. Candidate, ESE and Environment Ecological Engineering Student

BIO | Neha Shakelly is a PhD candidate in Environmental and Ecological Engineering at Purdue University, advised by Dr. John W. Sutherland. She holds a bachelor's degree in Aerospace Engineering from India, along with dual master's degrees in Aeronautics and Astronautics Engineering and Industrial Engineering from Purdue. Her research specializes in uncertainty quantification in emerging energy systems, with a focus on the techno-economic analyses (TEA) and life cycle assessments (LCA) of energy technologies, including bio-jet fuels, hybrid microgrids, and rare earth permanent magnets. During her PhD, Neha collaborated with multiple national laboratories, contributing to Department of Energy (DOE)-funded projects, and gained industry experience as a research intern at the National Renewable Energy Laboratory (NREL). Her work aims to enhance decision-making reliability in energy investments through advanced modeling and risk assessment techniques.

Dr. John W. Sutherland

Advisor

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